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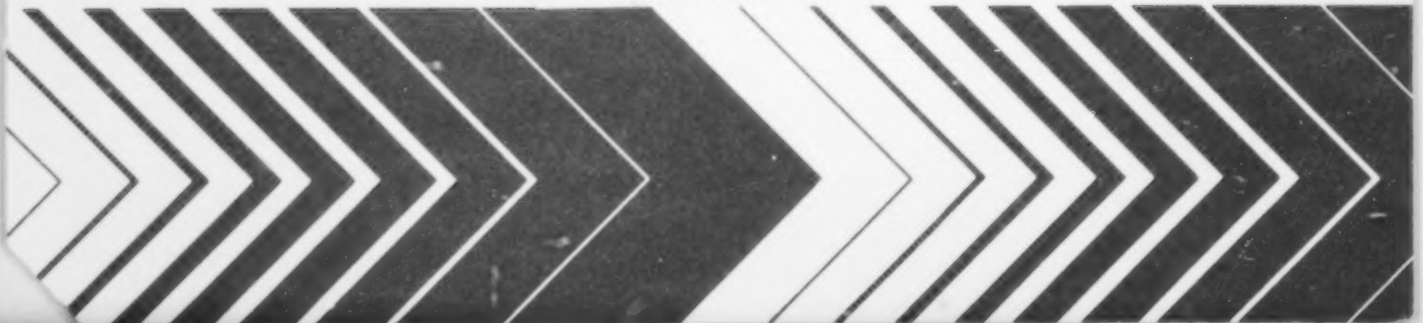

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ENVIRONMENTAL STATUS REPORT

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PREFACE

This report has been prepared as a part of "An Integrated Environmental Assessment of Federal Regions 4 and 6," being conducted by an interdisciplinary research team from the Science and Public Policy Program (S&PP) under a cooperative agreement with the Office of Strategic Assessment and Special Studies, Office of Research and Development, U.S. Environmental Protection Agency. The overall purpose of this study is to identify and assess future environmental trends in the region and to evaluate alternative strategies for environmental protection. This report is part of Phase I of the study (begun in October 1980) and is intended to summarize and synthesize existing information in order to identify key driving forces and both current and future environmental concerns. The report will serve as a basic reference document and the results will help to guide future study directions.

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The support staff in the Science and Public Policy Program also played a key role in producing this report. This includes: Mary Zimbelman, Assistant to the Director; Ellen Ladd, Clerical Supervisor, who spent tireless hours editing, proofreading, and compiling this material; and Nick Evans and Lennet Bledsoe, technical typists. The research support staff who also contributed greatly to the substance of this report includes: Martha Jordan, Librarian, and Rod Hedges, Research Team Assistant, who did most of the graphics for this report.

ABSTRACT

During the past several decades, the southern regions of the U.S. have experienced rapid change which is expected to continue into the foreseeable future. Growth in population, industry, and resource development has been attributed to several advantages such as a relatively inexpensive labor force, a mild climate, and the availability of natural resources--energy, water, land, and others. While this growth has tremendous economic benefits for the region, it can also create adverse environmental changes, including air and water pollution, solid waste disposal, modification of natural habitats, and hazardous material spills. The purpose of this Environmental Status Report is to summarize and synthesize existing information in order to identify key driving forces and both current and future environmental concerns in the region. It is part of a Southern Regional Environmental Assessment study, whose purpose is to identify long-term environmental changes in the region and to evaluate alternative strategies for balancing economic growth and environmental protection. The geographic scope of this study is the 13-state area comprising Federal Regions 4 and 6.

This report consists of three volumes. Volume I provides an overview of the research project, describes characteristics of the study area, and identifies general trends contributing to economic and environmental change in the southern region--including economic and population shifts, industrial growth, and social values and attitudes. Volume II examines in more detail growth in several economic sectors which are particularly important to the Sunbelt and are driving forces behind environmental change--energy development, chemical industry, textiles, agriculture and forestry, and the pulp and paper industry. Volume III describes the current status and future trends in several environmental categories: air quality, land and coastal zone use, water availability, water quality, and hazardous waste.

TABLE OF CONTENTS

SOUTHERN REGIONAL ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL STATUS REPORT

Page

Disclaimer ii
Preface iii
Abstract v
List of Figures xiii
List of Tables xvi
List of Acronyms and Abbreviations xxiii

INTRODUCTION xxvii

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 THE SUNBELT 1-1

1.2 REASONS FOR STUDYING THE SUNBELT. 1-2

1.3 THE SOUTHERN REGIONAL ENVIRONMENTAL ASSESSMENT. 1-8

1.4 ORGANIZATION OF THE ENVIRONMENTAL STATUS REPORT 1-11

CHAPTER 2: GROWTH AND CHANGE IN THE SUNBELT

HIGHLIGHTS 2-i

2.1 INTRODUCTION. 2-1

2.2 CHARACTERISTICS ENCOURAGING ECONOMIC GROWTH 2-3

2.3 CHARACTERISTICS ATTRACTING PEOPLE. 2-30

2.4 SUMMARY 2-41

Table of Contents (continued)

Page

CHAPTER 3: ECONOMIC AND POPULATION CHANGES

HIGHLIGHTS 3-i

3.1 INTRODUCTION. 3-1

3.2 ECONOMIC AND DEMOGRAPHIC PROJECTIONS. 3-1

3.3 POPULATION. 3-3

3.4 EMPLOYMENT. 3-17

3.5 INCOME. 3-26

3.6 BENEFITS OF GROWTH. 3-32

3.7 ENVIRONMENTAL PROBLEMS CREATED BY POPULATION GROWTH . . 3-33

3.8 SUMMARY 3-37

APPENDIX 3A: BUREAU OF ECONOMIC ANALYSIS PROJECTION METHODOLOGY 3-42

APPENDIX 3B: THE FOUR MAJOR REGIONS AS DEFINED IN THIS STUDY. 3-44
THE STANDARD FEDERAL REGIONS 3-44

APPENDIX 3C: SOUTHERN POPULATIONS: LARGE METROPOLITAN AREAS, 1960-1977 3-45

CHAPTER 4: INDUSTRIAL TRENDS

HIGHLIGHTS 4-i

4.1 INTRODUCTION. 4-1

4.2 METHODOLOGY 4-2

4.3 INDUSTRIAL TRENDS 4-4

4.4 GROWTH OF AGRICULTURE, MINING, AND MANUFACTURING INDUSTRIES. 4-7

4.5 REGIONS OF CONCENTRATED INDUSTRIAL ACTIVITY 4-21

4.6 SUMMARY 4-22

Table of Contents (continued)

Page

APPENDIX 4A: REGIONS 4 AND 6 EARNINGS BY INDUSTRY, BY STATE--1978 AND 2010. 4-25

CHAPTER 5: ENVIRONMENTAL VALUES AND ATTITUDES

HIGHLIGHTS. 5-i

5.1 INTRODUCTION 5-1

5.2 PUBLIC ATTITUDES ABOUT THE ENVIRONMENT 5-2

5.3 OTHER INDICATORS OF ENVIRONMENTAL SUPPORT. 5-20

5.4 SUMMARY. 5-23

CHAPTER 6: ENERGY PRODUCTION AND CONSUMPTION

HIGHLIGHTS. 6-i

6.1 INTRODUCTION 6-1

6.2 SOUTHERN ENERGY TRENDS 6-2

6.3 PETROLEUM AND NATURAL GAS. 6-10

6.4 DIRECT USE OF COAL 6-24

6.5 SYNTHETIC FUELS FROM COAL AND OIL SHALE. 6-37

6.6 NUCLEAR ENERGY RESOURCES 6-53

6.7 RENEWABLE BIOMASS ENERGY 6-67

6.8 PEAT AS AN ENERGY RESOURCE 6-77

6.9 GEOTHERMAL ENERGY RESOURCES. 6-88

6.10 SUMMARY 6-99

Table of Contents (continued)

Page

CHAPTER 7: THE CHEMICAL INDUSTRY

HIGHLIGHTS. 7-i

7.1 INTRODUCTION 7-1

7.2 CURRENT STATUS 7-2

7.3 FUTURE DEVELOPMENT AND ENVIRONMENTAL ISSUES. 7-17

7.4 SUMMARY. 7-29

CHAPTER 8: THE TEXTILE INDUSTRY

HIGHLIGHTS. 8-i

8.1 INTRODUCTION 8-1

8.2 CURRENT STATUS AND FUTURE TRENDS 8-2

8.3 ENVIRONMENTAL CONCERNS 8-7

8.4 SUMMARY. 8-11

CHAPTER 9: AGRICULTURAL DEVELOPMENT AND FOREST MANAGEMENT

HIGHLIGHTS. 9-i

9.1 INTRODUCTION 9-1

9.2 AGRICULTURAL DEVELOPMENT 9-2

9.3 FOREST LAND AND TIMBER PRODUCTS. 9-38

9.4 SUMMARY. 9-50

APPENDIX 9A: INSECTICIDE AND HERBICIDE USE ON MAJOR FIELD CROPS, HAY, PASTURE, AND RANGELAND. . 9-56

CHAPTER 10: THE PULP AND PAPER INDUSTRY

HIGHLIGHTS. 10-i

10.1 INTRODUCTION 10-1

Table of Contents (continued)

Page

10.2 PULP AND PAPERMAKING PROCESS 10-1

10.3 CURRENT STATUS 10-4

10.4 FUTURE DEVELOPMENTS 10-9

10.5 ENVIRONMENTAL CONCERNS. 10-13

10.6 SUMMARY 10-22

CHAPTER 11: AIR QUALITY

HIGHLIGHTS. 11-i

11.1 INTRODUCTION. 11-1

11.2 EXISTING CONDITIONS 11-1

11.3 TRENDS AND ISSUES 11-36

11.4 SUMMARY 11-53

APPENDIX 11A: BOUNDARIES OF AIR QUALITY CONTROL REGIONS. . 11-62

APPENDIX 11B: COMPARISON OF POLLUTION STANDARD INDEX . . . 11-63

APPENDIX 11C: PARTICULATE EPISODE CRITERIA 11-64

CHAPTER 12: LAND AND COASTAL ZONE USE

HIGHLIGHTS. 12-i

12.1 INTRODUCTION. 12-1

12.2 EXISTING CONDITIONS 12-1

12.3 TRENDS AND ISSUES 12-15

12.4 SUMMARY 12-48

Table of Contents (continued)

Page

CHAPTER 13: WATER AVAILABILITY

HIGHLIGHTS. 13-i

13.1 INTRODUCTION. 13-1

13.2 EXISTING CONDITIONS 13-1

13.3 FUTURE TRENDS AND ISSUES. 13-15

13.4 SUMMARY 13-41

APPENDIX 13A: METHODOLOGY AND ASSUMPTIONS OF THE SECOND NATIONAL WATER ASSESSMENT. 13-48

CHAPTER 14: WATER QUALITY

HIGHLIGHTS. 14-i

14.1 INTRODUCTION. 14-1

14.2 EXISTING CONDITIONS 14-2

14.3 FUTURE TRENDS AND ISSUES. 14-28

14.4 SUMMARY 14-47

CHAPTER 15: HAZARDOUS WASTES

HIGHLIGHTS. 15-i

15.1 INTRODUCTION 15-1

15.2 CURRENT STATUS 15-2

15.3 FUTURE TRENDS AND ISSUES 15-15

15.4 SUMMARY. 15-25

APPENDIX 15A: SUMMARY OF RCRA REGULATIONS. 15-31

LIST OF FIGURES

Page

1-1: The Sunbelt Study Area 1-2
1-2: Manufacturing Employment 1-4
1-3: Population Growth. 1-4
1-4: Consumptive Energy Use 1-6
1-5: Growth of Agricultural Earnings (%): 1978-2010. 1-6
1-6: Organization of the Environmental Status Report. 1-12
2-1: (a) Population Growth Rate, (b) Employment Growth Rate, and (c) Per Capita Income for the South and Nonsouth 2-2
2-2: Employment in Basic Industries in the South, 1920-1980 2-6
3-1: Regional Population as a Percentage of the U.S. Total 3-5
3-2: Population Growth Rates in the Sunbelt States 3-7
3-3: Average Annual Population Growth Rate 3-9
3-4: Net Interregional Migration, 1970-1975 3-11
3-5: Percentage of Counties Experiencing Net Outmigration Loss or Net Population Loss. 3-15
3-6: Rate of Change in Total Employment and Manufacturing Employment 3-22
5-1: Percent Saying That We're Spending "Too Little" on Eleven Problems 5-4
5-2: Rating Improvements in Local Air And Water Quality Over the Past Five Years 5-6
5-3: Views of the Environmental Movement. 5-7
5-4: Views About Pollution Control, 1977-1980 5-9
5-5: Cumulative Percentage of People Willing to Accept New Industrial Installation at Various Distances From Their Homes 5-17
6-1: Consumptive Energy Use. 6-4
6-2: Coal Fields of the Coterminous United States. 6-26
6-3: Distribution of U.S. Oil Shale Resources. 6-41
6-4: Coal Gasification and Liquefaction Projects 6-43
6-5: Operating Uranium Mills in the U.S., January 1, 1980 6-56

List of Figures (continued)

Page

6-6: Nuclear Power Reactors in the U.S.. 6-60
6-7: Proposed Sites for a Permanent High Level Radioactive Waste Repository. 6-63
6-8: Usable Crop Residues and Potential Near-Term Herbage Production. 6-73
6-9: North Carolina Peat Resource Areas. 6-81
6-10: Florida Peat Resource Areas 6-83
6-11: Louisiana Peat Resource Areas 6-85
6-12: Known and Potential Hydrothermal Resources. 6-91
6-13: Texas Geothermal Resource Regions 6-93
7-1: World Chemical Production 7-19
7-2: Water Use by the Chemical Industry. 7-23
9-1: Energy and Fertilizer Requirements to Achieve Moderate Growth Projections 9-27
9-2: Commercial Timberland as a Percentage of Land Area 9-40
10-1: Southern Pulp Mills in 1977 10-7
10-2: Capital Expenditures for Pollution Abatement, 1973-1978. 10-11
11-1: Isopleths of Total Number of Forecast-Days of High Meteorological Potential for Air Pollution, etc. . 11-6
11-2: Emissions of Criteria Pollutants in 1975 11-16
11-3: Regions 4 and 6 Nonattainment. 11-26
11-4: Violations of Ozone Standards. 11-27
11-5: Air Quality Control Regions in Region 6: etc. . . . 11-39
11-6: Air Quality Control Regions in Region 4: etc. . . . 11-41
11-7: Sensitivity to Acid Rain 11-44
11-8: Projected Nonattainment Areas for Regions 4 and 6. . 11-48
11-9: Class I Areas in Region 6. 11-50
11-10: Class I Areas in Region 4. 11-51
12-1: Natural Ecoregions of the Sunbelt. 12-6
12-2: South Atlantic Coastal Area. 12-12
12-3: Gulf Coast and South Florida Coastal Areas 12-14
12-4: Land Use Patterns in the U.S. and the Sunbelt. . . . 12-16
12-5: Bottomland Hardwood Forest Clearing Rate Comparison. 12-33
12-6: Potential Coal Strip Mining Areas. 12-36
12-7: Distribution of Important Resource Problems. 12-50
13-1: Surface Water Laws 13-3
13-2: Water Resources Regions. 13-7
13-3: Annual Precipitation 13-8
13-4: Ground Water Resources of the Sunbelt. 13-9
13-5: Projected Water Consumption in the Sunbelt 13-16

List of Figures (continued)

Page

13-6: Water Use by the Chemical Industry, 1975-2000. . . . 13-21
13-7: Ground Water Overdraft and Related Problems. 13-24
13-8: The Ogallala Aquifer 13-28
13-9: Ground Water Mining, Ogallala Aquifer, Hale County, Texas 13-29
13-10: Principal Sources of Ground Water in Florida 13-31
13-11: Current Region-Wide Problems: Water Availability. . 13-33
13-12: Significant Water Quality Problems in the South. . . 13-34
13-13: Tennessee-Tombigbee Waterway 13-36
14-1: Surface Water Pollution Problems from Point Sources. 14-8
14-2: Surface Water Pollution Problems from Nonpoint Sources. 14-11
14-3: Erosion and Sedimentation. 14-13
14-4: Oil Spill Data 14-14
14-5: Ground Water Pollution Problems. 14-19
14-6: Drinking Water Quality Problems. 14-27
15-1: Hazardous Waste Management System. 15-18

LIST OF TABLES

Page

1-1: The Southern Regional Environmental Assessment. 1-9
2-1: Structure of Employment in the South and Nonsouth, 1920. 2-5
2-2: Median Wage or Salary Income for Males, 1969. 2-8
2-3: Labor Union Membership as a Percent of Nonagricultural Employment, 1978. 2-9
2-4: Days Idled Due to Work Stoppages per Nonagricultural Employee, 1978 2-10
2-5: Average Retail Price of Energy to Industrial Users, 1980. 2-13
2-6: Rates of Growth of Energy-Intensive Industries. . . . 2-15
2-7: Sunbelt Share and Growth of Raw Material Oriented Industries, 1978 2-17
2-8: Regional Imbalances in Federal Spending and Taxes, 1979. 2-25
2-9: Southern State Imbalances in Federal Spending and Taxes, 1979. 2-26
2-10: Regional Population by Size of Metropolitan Area, 1977. 2-34
2-11: Urban Intermediate Budget for a Four-Person Family, 1978. 2-37
2-12: 1970 Quality-of-Life Rating for States in the Study Area. 2-39
3-1: Regional Distribution of Population 1960-2000 3-4
3-2: Total Population by State for the Southern Region . . 3-6
3-3: Net Migration for the Southern Region 3-10
3-4: Metropolitan and Nonmetropolitan Population Growth. . 3-13
3-5: Increase in the Proportion and Number of Persons Over 65 in the South. 3-17
3-6: Employment by Region and State, 1969-2010 3-18
3-7: Change in Manufacturing Employment, 1978-2010 3-20
3-8: Index of Employment/Population, 1969-2010 3-23
3-9: Unemployment and Labor Force Participation Rates. . . 3-25
3-10: Per Capita Income 3-27
3-11: Earnings Per Employee 3-28
3-12: Geographic Distribution of Change in Per Capita Income. 3-30
3-13: Percentage of Population Below Poverty Level. 3-31

List of Tables (continued)

Page

4-1: Region 4 Sector Earnings 4-5
4-2: Region 6 Sector Earnings 4-6
4-3: Region 4 Earnings in Manufacturing, Mining, and Agriculture. 4-9
4-4: Region 6 Earnings in Manufacturing, Mining, and Agriculture. 4-10
4-5: States Projected to Have High Earnings in Selected Industries in 2010 4-11
5-1: Self Identification as an "Environmentalist" 5-8
5-2: Views of Sunbelt Residents About Pollution Control in 1980. 5-10
5-3: Views About Economic Growth and Environmental Protection 5-11
5-4: Public Attitudes Toward Building a Plant On a Marsh Which Supports a Rare Bird Species 5-12
5-5: Public Attitudes Toward Habitat Protection for Wildlife 5-13
5-6: Public Attitudes Toward Natural Resource Development by Region. 5-14
5-7: Views on the Use of Nuclear Power in the U.S. by Region. 5-16
5-8: Support for Government Prohibition of Various Chemical Risks 5-19
5-9: Emphasis on Environmental Issues by States in Regions 4 and 6 5-21
6-1: Gross Energy Consumption by End-Use Sector. 6-6
6-2: Energy Consumption by Major Fuel Sources. 6-7
6-3: Electricity Generation: Capacity and Units by Fuel Type 6-9
6-4: Proved Reserves of Petroleum and Natural Gas. 6-11
6-5: Petroleum and Natural Gas Production. 6-14
6-6: Operating Refineries in the Sunbelt 6-16
6-7: Future Production of Petroleum and Interstate Gas 6-18
6-8: Intrastate Gas Production Projections 6-19
6-9: Well Drilling Activity. 6-20
6-10: Selected Environmental Issues for Oil and Gas Development 6-22
6-11: Coal Production and Use 6-25
6-12: Recoverable Coal Reserves as of January 1, 1976 . . . 6-27
6-13: Recoverable Coal Reserves from Producing Mines, 1979. 6-29

List of Tables (continued)

Page

6-14: Coal Production Projections 6-30
6-15: Electricity Generating Capacity from Coal Steam . . . 6-32
6-16: Annual Coal Requirements for Electric Utilities . . . 6-34
6-17: Selected Environmental Issues in the Production and Direct Use of Coal. 6-35
6-18: Resource Requirements Associated with Synfuel Conversion Technologies, Based on Preliminary Design Studies. 6-39
6-19: Devonian Oil Shale Resources Recoverable by IGT HYTORT Process. 6-42
6-20: Coal Gasification and Liquefaction Projects 6-44
6-21: Selected Environmental Issues for Synfuels. 6-50
6-22: Distribution of Uranium Reserves. 6-55
6-23: Land Held for Uranium Exploration and Mining. 6-57
6-24: 1979 Uranium Drilling 6-58
6-25: The Market for Nuclear Power. 6-58
6-26: Nuclear Generating Capacity in the Sunbelt. 6-61
6-27: Selected Environmental Issues for Nuclear Energy. . . 6-65
6-28: Biomass Energy Products, Feedstocks, and Costs. . . . 6-69
6-29: Fossil Fuel Costs, Mid-1980 6-70
6-30: Estimates of Biomass Energy Potential by 2000 6-71
6-31: Selected Environmental Issues of Biomass Fuels Production. 6-76
6-32: Estimated U.S. Peat Reserves and Potential Energy . . 6-79
6-33: Selected Environmental Issues of Peat Development . . 6-87
6-34: National Geothermal Utilization Goals 6-89
6-35: Estimates of Total Geopressured Resource, Onshore/ Offshore the Texas-Louisiana Gulf Coast 6-95
6-36: Selected Environmental Issues of Geothermal Development 6-97
7-1: Shipments and Capital Investment in the Manufacturing Sector and in Chemicals by State. 7-4
7-2: Value of Shipments by State and by Sector of the Chemical Industry 7-5
7-3: Leading Sectors of the Chemical Industry by State . . 7-6
7-4: Employment and Income by State in Manufacturing and in the Chemical Industry, 1977. 7-8
7-5: Growth of Manufacturing and the Chemical Industry, 1972-1977 7-11
7-6: Oil and Gas and Oil Refining Industries 7-13
7-7: Federal Laws Dealing with Toxic Substances. 7-15
7-8: Industry Capital Spending for Pollution Control Projects. 7-16

List of Tables (continued)

Page

7-9: Industries Seen as Having Done a "Poor Job" of Complying with [Environmental] Laws and Guidelines. 7-18
7-10: Reported and Projected Industry Earnings for Chemicals and Allied Products 7-21
7-11: Feedstock, Petrochemicals, and Industries Dependent on Petrochemicals 7-28
8-1: Textile Industry Employment 8-3
8-2: Textile Industry Earnings 8-4
8-3: Industry Employment--Textiles as a Percent of Total Manufacturing 8-5
8-4: Industry Earnings--Textiles as a Percent of Total Manufacturing. 8-5
8-6: Estimates of Textile Solid Waste, 1974. 8-10
9-1: Agricultural Land Use in Regions 4 and 6, 1977. . . . 9-3
9-2: Cash Receipts From Farm Marketing, 1979 9-5
9-3: Acreage Planted to Major Crops, 1981. 9-7
9-4: Fertilizers Applied to Harvested Acreages 9-8
9-5: Insecticide Use on Major Crops in the South and the U.S 9-11
9-6: Pesticide Application Rates in the South. 9-13
9-7: Insecticide Application Rates to Selected Major Crops, by Region. 9-14
9-8: Herbicides Used on Major Crops in the South and the U.S 9-16
9-9: Herbicide Application Rates to Selected Major Crops, by Region. 9-17
9-10: Irrigated Land in the Sunbelt 9-19
9-11: Land Use Shifts, 1967 to 1975 9-22
9-12: Current Cropland and Nonfederal Land in Other Uses with Cropland Conversion Potential, 1977 . . . 9-23
9-13: Projected Growth in Agricultural Industry Earnings. . 9-25
9-14: Major Factors Affecting Crop Production 9-26
9-15: Low-Till Farming in the South by Region 9-30
9-16: Production and Export of Wheat, Soybeans, Feedgrains, and Cotton. 9-33
9-17: Water, Soil, and Herbicide Leaving Conventional and No-Till Corn Fields 9-37
9-18: Forest Land Area by Ecosystem and Section, Region, and State, 1977 9-41
9-19: Ownership of Commercial Forest in 1977. 9-42
9-20: Net Annual Growth and Removal of Growing Stock, 1976 9-44

List of Tables (continued)

Page

9-21: Historic and Projected U.S Demand for Lumber and Plywood 9-45
9-22: Projected Roundwood and Sawtimber Supplies in the South and U.S. 9-47
9-23: Projected Growth in Lumber Products Industry Earnings. 9-48
10-1: Southern Pulping Capacity by Process Type 10-3
10-2: Pulpwood Production in the South, 1978. 10-5
10-3: Woodpulp Supply and Consumption 10-5
10-4: Southern Pulp Mill Capacity, 1977 10-6
10-5: Paper and Board Production, 1978. 10-8
10-6: Consumption of Paper and Board. 10-9
10-7: Pulp and Paper Earnings, 1978-2010. 10-14
10-8: Freshwater Withdrawals and Consumption. 10-15
10-9: Proposed Pulp and Paper Mill Effluent Guidelines 10-17
10-10: Pulp Mill Effluent. 10-18
10-11: Average Annual Pulp and Paper Discharge Levels. . . . 10-19
10-12: Toxic Pollutants of the Pulp and Paper Industry . . . 10-23
11-1: Major Regulatory Mechanisms for Air Pollution Control. 11-2
11-2: State Contribution to Regional Emissions of Criteria Pollutants, 1978. 11-8
11-3: Major Sources of Criteria Pollutants for States in Region 4, 1978. 11-9
11-4: Major Sources of Criteria Pollutants for States in Region 6, 1978. 11-13
11-5: Emissions Inventories, Region 4. 11-18
11-6: Frequency of Violations of EPA Criteria Pollutant Standards by Counties in the Ten Federal Regions, 1978. 11-24
11-7: PSI Values for Six Southern SMSA's, 1976-1978. . . . 11-29
11-8: Cities in Nonattainment Areas, Region 4, 1976-1977 . 11-30
11-9: Birmingham Particulate Episodes, 1971-1981 11-32
11-10: Program Status for Potentially Hazardous Air Pollutants Under CAA 11-35
11-11: Major Sources of Trace Element Emissions for Regions 4 and 6, 1975. 11-36
11-12: Annual SO_2 and NO_x Emissions, 1975-1990. 11-40
11-13: Regional Distribution of Tall Stacks Built by Electric Utilities, 1970-1979 11-45

List of Tables (continued)

Page

11-14: Problem Characterization Matrix: Air Quality. . . . 11-54
12-1: Federal Statutes Regulating Surface Uses 12-3
12-2: Summary of State Regulations Protecting Critical Habitats and Endangered Species. 12-4
12-3: Selected Legislation on Land Use and Environmental Controls in Florida. 12-5
12-4: Major Natural Ecosystem Types in the Southern Region. 12-7
12-5: Wetland Areas of the Southern Region, 1956 12-10
12-6: Coastal Zone Modification. 12-11
12-7: Forestland of the Sunbelt by Ownership and Management Agency, 1977. 12-21
12-8: Rangeland of the Sunbelt by Ownership and Management Agency, 1977. 12-22
12-9: Protected Acreage Within the Southern Region 12-24
12-10: Pesticide Residues in Agricultural Soils 12-27
12-11: Representative Erosion Rates with Various Land Uses. 12-28
12-12: Erosion From Cropland in the U.S., 1977. 12-29
12-13: Cropland Soil Erosion Due to Water and Wind, 1977 12-31
12-14: Conversion of Land to Urban, Transportation, and Water Uses, 1967-1977. 12-32
12-15: Soil Conservation Service Assessment of Land Disturbed by Surface Mining as of July 1, 1977 12-34
12-16: Environment Change 1952-1974 for the Mississippi Delta. 12-38
12-17: Commercial and Marine Recreational Fisheries Catch by State 12-40
12-18: Examples of Coastal Water Improvement. 12-41
12-19: Numbers of Species Federally Designated as Endangered, Threatened, Proposed, or In-Review, September, 1978. 12-46
12-20: Examples of Critical Habitat 12-47
12-21: Important Resource Problems in Federal Regions 4 and 6 Identified for 1980-85 12-49
12-22: Environmental Matrix: Land and Coastal Zone Use 12-51
13-1: Treaties and Compacts Affecting Water Resources in the Sunbelt 13-5
13-2: Fresh Water Use in Water Regions of the Sunbelt, 1975 13-10

List of Tables (continued)

Page

13-3: Water Withdrawals in Region 6, 1975. 13-11
13-4: Water Consumption in Region 6, 1975. 13-12
13-5: Water Withdrawals in Region 4, 1975. 13-13
13-6: Water Consumption in Region 4, 1975. 13-14
13-7: Water Consumption in Region 6, 1975 and 2000 13-17
13-8: Water Consumption in Region 4, 1975 and 2000 13-18
13-9: Manufacturing Water Use and Growth Projections . . . 13-20
13-10: Water Use by Major Industries in Key Resource Regions, 1975-2000 13-22
13-11: Ground Water Management in Sunbelt States. 13-25
13-12: Problem Characterization Matrix: Water Availability 13-42
14-1: Water Pollution Impacts from Point Sources, 1977. 14-7
14-2: Nonpoint Pollution 14-10
14-3: Summary of Ground Water Quality in Regions 4 and 6 14-18
14-4: National Interim Primary Drinking Water Standards. 14-24
14-5: Organic Compounds Found in Ground Water 14-25
14-6: Significant Potential Water Pollution Sources. . . . 14-29
14-7: Point Source Pollution Trends. 14-33
14-8: Estimated Mix of U.S. Urban Runoff Pollution 14-37
14-9: Projections of Agricultural Pollutants 14-40
14-10: State Ground Water Protection Programs 14-45
14-11: Problem Characterization Matrix: Water Quality. 14-48
15-1: Major Provisions of the Resource Conservation and Recovery Act of 1976 15-3
15-2: Summary of Hazardous Waste Generated by Federal Region, 1975. 15-7
15-3: 1980 Industrial Hazardous Waste Generation by Industry, by Federal Region 15-9
15-4: Hazardous Wastes Generated by Industries Grouped by Standard Industrial Classification by State 15-13
15-5: Growth Projections for Major Hazardous Waste Generators 15-16
15-6: Problem Characterization Matrix: Hazardous Wastes 15-26

LIST OF ACRONYMS AND ABBREVIATIONS

AFY	acre-feet per year
AQCR	Air Quality Control Region
BACT	best available control technology
BAT	best available technology economically achievable
bbl/cd	barrels per calendar day
bbl/d	barrels per day
BCT	best conventional pollutant control technology
bgd	billion gallons per day
BEA	Bureau of Economic Analysis
bgpy	billion gallons per year
BLM	Bureau of Land Management
BMP	best management practices
BOD	biological oxygen demand
bpdoe	barrels per day oil equivalent
CAA	Clean Air Act
CEQ	Council on Environmental Quality
cfd	cubic feet per day
cfs	cubic feet per second
C/km	degree centigrade per kilometer
CO	carbon monoxide
COD	chemical oxygen demand
CO_2	carbon dioxide
CWA	Clean Water Act
CWP	coal workers' pneumoconiosis
DOE	Department of Energy
DOI	Department of the Interior
EPA	Environmental Protection Agency
FWPCA	Federal Water Pollution Control Act
GAC	granular activated carbon
GAO	General Accounting Office
GNP	Gross National Product
gpd	gallons per day
GSU	Gulf States Utilities Company
HBG	High-Btu Gas
HC	hydrocarbons
H_2S	hydrogen sulfide
IGT	Institute for Gas Technology
IPM	Integrated Pest Management
IRPS	Important Research Problems
LBG	Low-Btu Gas
MAFY	thousand acre-feet per year

MBG	Medium-Btu Gas
mg/l	milligrams per liter
ml	milliliter(s)
MMAFY	million acre-feet per year
MMbbl	million barrels
MMbbl/d	million barrels per day
MMgpy	million gallons per year
MMscf/d	million standard cubic feet per day
mrem	millirem
MW	megawatt(s)
NAAQS	National Ambient Air Quality Standards
NCA	National Coal Association
NCAQ	National Commission on Air Quality
NEDS	National Emissions Data System
NO_x	oxides of nitrogen
NO_2	nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NSPS	New Source Performance Standards
OECD	Organization for Economic Cooperation and Development
OSHA	Occupational Safety and Health Administration
OTA	Office of Technology Assessment
O_x	photochemical oxidants
PCB	polychlorinated biphenyl
pCi/l	picocuries per liter
PVC	polyvinyl chloride
pH	acidity/alkalinity
ppb	parts per billion
ppm	parts per million
PSD	prevention of significant deterioration
PSI	Pollutant Standard Index
Q or quad	quadrillion Btu
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RFF	Resources for the Future
S&PP	Science and Public Policy Program
SEAS	Strategic Environmental Assessment System
SIC	Standard Industrial Classification
SIP	State Implementation Plans
SMCRA	Surface Mining Control and Reclamation Act
SMSA	Standard Metropolitan Statistical Area
SO_x	oxides of sulfur
SO_2	sulfur dioxide
SO_4	sulfate
SWRI	Southwest Research Institute
TCE	trichloroethylene
tcf	trillion cubic feet
TOSCA	Toxic Substances Control Act
tpd	tons per day

tpy	tons per year
TSP	total suspended particulates
tu	turbidity units
TVA	Tennessee Valley Authority
$\mu g/m^3$	micrograms per cubic meter
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
U_3O_8	uranium oxide and/or yellowcake

INTRODUCTION

This is an environmental status report produced as part of Phase I of the Southern Regional Environmental Assessment (SREA). The purpose of the total study is to identify and assess trends in Regions 4 and 6 and to evaluate alternative strategies for environmental protection. This report summarizes and synthesizes existing information on the study area. It describes prevailing characteristics and trends in the economics and the environment of the Sunbelt. It is intended to serve as a basic reference and guide to future study directions.

Chapters 1 through 5 introduce the study and describe key characteristics of the study area--those which are likely to create or be affected by environmental problems. Chapter 1 provides a brief overview of the Sunbelt Study area and the reasons for studying it. Chapter 1 also describes the concepts and purposes of the SREA and identifies Phase I activities. Chapter 2 examines the causes of population and economic growth in the South. The first section deals with factors encouraging economic growth, including resource cost and availability, development of regional markets, transportation systems, and governmental policies. The second part addresses those characteristics which may attract people, including the effects of amenities on retired and labor force migration and on industrial siting decisions. Chapters 3 and 4, building on the economic and demographic forces presented in Chapter 2, discuss economic, population, and industrial trends in the study area. Chapter 3 profiles the current and projected patterns of southern growth and change by comparing population, income, and employment across the study area. It identifies unique characteristics of the southern region and describes how the changing structure of the southern economy cannot only bring many benefits but can also adversely affect the environment. Chapter 4 presents an industrial profile of the study area. Key industries likely to cause environmental change are identified, growth projections are presented, and probable locations for growth industries are discussed. Chapter 5 discusses the social and political context within which decisions about economic development and environmental protection are made. It depicts public attitudes and values about the environment; trade-offs among the environment, energy, and economics; and the factors determining the degree of public support for environmental issues.

Chapters 6 through 10 discuss in detail some of the key causal factors likely to be associated with environmental change in the southern regions. Chapter 6 begins with a discussion of energy consumption and production patterns in the area. The remainder of the chapter examines current status and potential developments in oil and gas, coal, synthetic fuel, biomass, nuclear, peat, and geothermal energy resources. Anticipated locations and environmental impacts of these developments are discussed. Chapters 7 through 10 describe key economic sectors in terms of their current status and forecasted economic growth and the environmental implications of those developments. The following categories are included: the chemical industry, textiles, agriculture and forestry, and the pulp and paper industry.

Chapters 11 through 15 discuss five categories of environmental concerns: air quality, land and coastal zone uses, water availability, water quality, and hazardous wastes. Each of these chapters links the environmental concerns in that category to one or more of the driving forces discussed in Chapters 6 through 10. Each begins with a brief description of the regulatory system for controlling environmental problems in the category of concern. The emphasis in these descriptions is on federal legislation and regulations. The descriptions are followed by overviews of existing conditions in the study area; for example, water quality conditions and problems are discussed according to surface water (including both point and nonpoint sources of pollution), ground water, and drinking water. The next section of each chapter discusses future trends and issues. First, the environmental concerns in that category are linked to the driving forces identified in Chapters 1 through 10. For example, future air quality in the southern region is influenced by rapid metropolitan growth, expanded use of coal resources, and growth of chemical, pulp and paper, and construction materials industries. Next, categories of key environmental problems and policy issues are discussed. Each chapter then concludes with a summary organized around an environmental problem characterization matrix which systematically links key environmental problems to driving forces and policy issues.

CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 THE SUNBELT

The southern regions of the U.S.--commonly referred to as the Sunbelt--have been undergoing rapid change during the past two decades. This area is shown in Figure 1-1.[1] Among the most significant changes are: large population increases, diverse industrial expansion, agricultural growth, and alterations in land-use patterns. Many of these changes are expected to continue and several will accelerate over the next two or three decades. The purposes of this Environmental Status Report are:

- To characterize the nature of growth and change in the Sunbelt, including the reasons why the region has been changing;
- To identify the most significant driving forces of future changes; and
- To describe both the variety of benefits associated with growth and the environmental and natural resource management problems which could accompany growth.

This report is not intended to provide analyses of policy responses for dealing with growth-related problems; rather it is intended to provide a broad overview of the Sunbelt which can serve as the foundation for future, more policy-oriented studies.[2]

The remainder of this chapter provides an overview of the purposes of this report and the overall "Sunbelt" assessment. The

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[1] Throughout this report, the terms "Sunbelt" and "southern region" will be used to refer to our study area, which consists of Federal Regions 4 and 6. While there is no uniform definition of the Sunbelt, this study area is very close to the most frequently used classifications (see Browning and Gesler, 1979). Other states often included are Arizona and California, while Kentucky is often excluded.

[2] Future reports intended from this project are described in section 1.3 below.

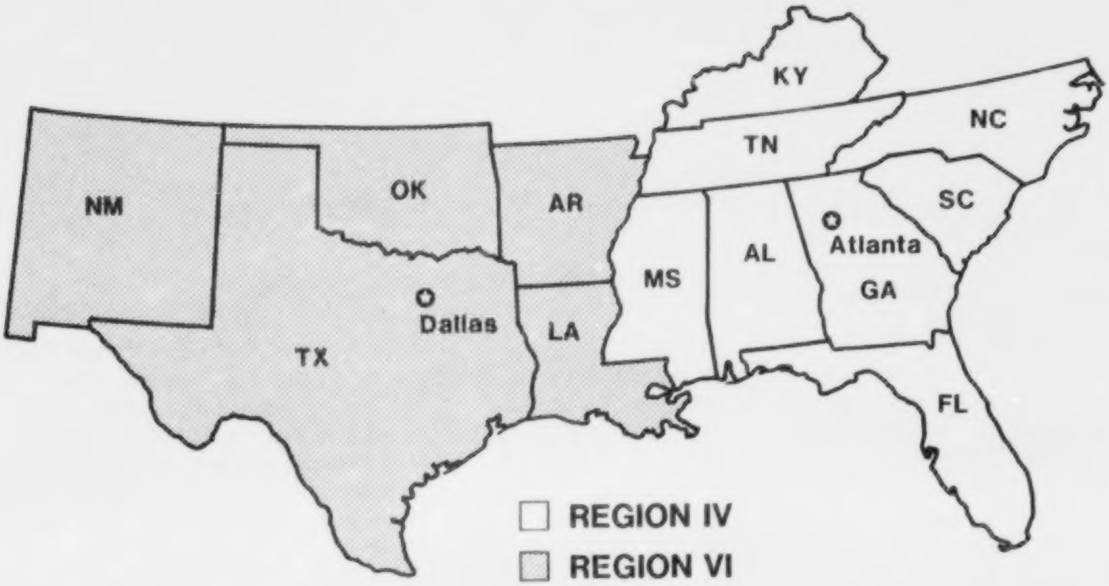

Figure 1-1: The Sunbelt Study Area

next section (1.2) discusses the objectives of regional analysis and briefly characterizes the driving forces which shape the Sunbelt. Section 1.3 discusses the purposes and scope of this report and describes future activities. A final section (1.4) describes the organization of this report.

1.2 REASONS FOR STUDYING THE SUNBELT

1.2.1 Objectives of Regional Assessments

Growth patterns, environmental conditions, and policies to deal with growth-related problems differ substantially across regions of the country. This perspective is often lost in environmental assessments directed towards a particular industry, such as electric utilities, or a specific environmental problem, such as hazardous waste disposal. Regional assessments are not intended to replace these specific approaches; their purpose is to supplement them by taking a broad picture of a particular region. Such a broad perspective provides a context for understanding relationships among specific issues in the region; it also can help in making comparisons among regions and developing knowledge bases which may be transferrable to other regions.

Specific objectives of regional assessments are:

- To help establish priorities for environmental protection by addressing the relative magnitude of issues across environmental media, across industries, and across geographical areas. Of the variety of potential issues in a region, which ones deserve priority attention?
- To identify cumulative impacts resulting from multiple developments; for example, how will multiple industrial sitings affect water resources in an area?
- To identify cross-media impacts; for example, how will policies designed to protect air quality in a region affect water and/or land resources?
- To assess policy options for balancing economic growth and environmental goals. What are the options, which are most appropriate, and who should have responsibility for implementing them?
- To prioritize information and research needs. What key issues or potential solutions require the most immediate research attention?

1.2.2 Importance of the Sunbelt as a Region

Several factors contribute to the significance of the Sunbelt. These include population increases; industrial growth including the chemical, textile, and pulp and paper industries; increased energy production and consumption; and changes in agriculture and forestry. A few of the most significant of these factors are summarized below.[1]

Industrial growth has been a key driving force throughout much of the Sunbelt. Figure 1-2 shows one indicator of industrial growth--manufacturing employment by region as a percentage of the U.S. total (U.S., Dept. of Commerce, BEA, 1980). In 1960, only about 17 percent of those employed in manufacturing worked in the Sunbelt. Since that time, the Sunbelt has had by far the fastest rate of growth. By 2010, this region is projected to account for 32 percent of the total U.S. manufacturing employment--more than any other region.

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[1] These and other key driving forces are elaborated in volumes I and II of this report. See section 1.4 below.

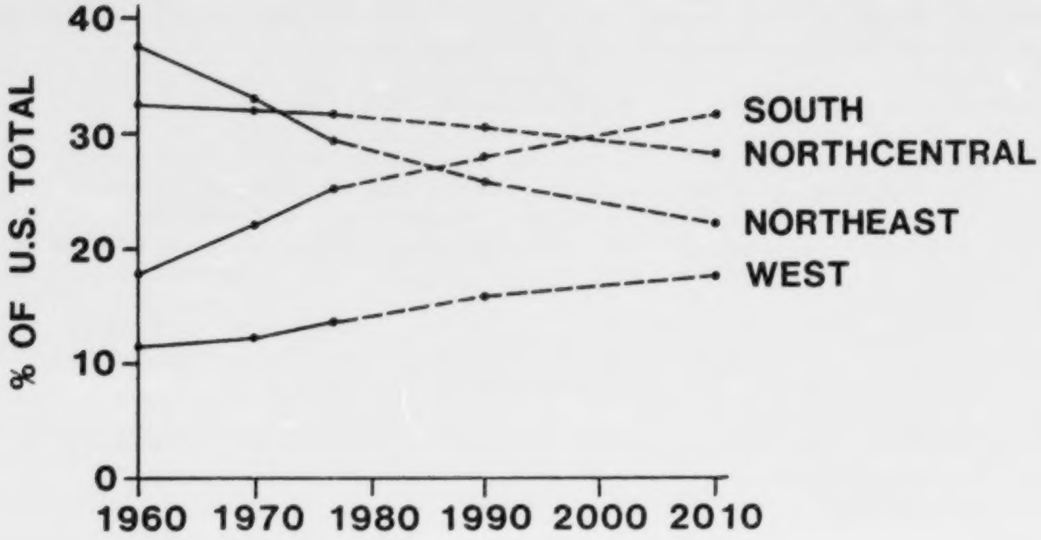


Figure 1-2: Manufacturing Employment

Source: U.S., Department of Commerce, BEA, 1980, (see Chapter 3).

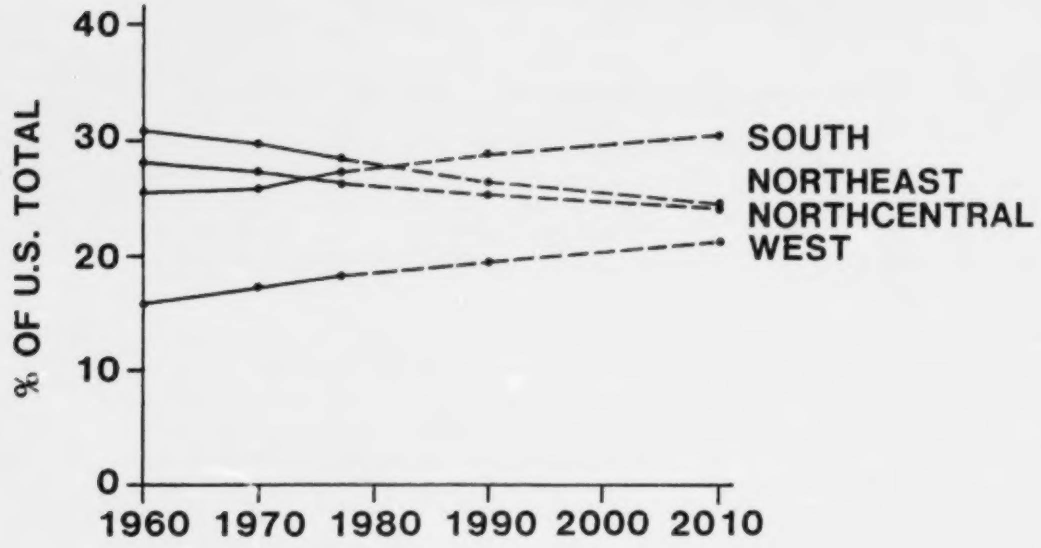


Figure 1-3: Population Growth

Source: U.S., Department of Commerce, BEA, 1980, (see Chapter 3).

Population is a second key driving force, as suggested in Figure 1-3. Since 1960, the South and West have been the fastest growing regions in the nation. Before the end of this decade, the South is projected to be the most populous region of the U.S. and by 2010, over 30 percent of the U.S. population is projected to live in these 13 states. In absolute terms, this means growth from 45 million in 1960 to over 85 million by 2010.

Adequate energy supplies are essential to growth of population and industry. Figure 1-4 shows projected regional energy consumption as a proportion of total U.S. energy consumption. From 1960 to 1975, energy consumption in the South grew at a faster rate than in other regions. This was largely due to rapid growth in the transportation and energy-intensive industrial sectors. The forecast of energy consumption through the year 2000 reflects the combined influence of several factors: population and industrial growth, conservation, and fuel switching from oil to coal and nuclear power. The combination of these effects is projected to result in the South consuming over one-third of total U.S. energy through the year 1995 (U.S., DOE, 1980).

In addition to population, industrial, and energy growth, land use changes will be important to the future of the Sunbelt. Projected land use changes include increased agricultural activity, increased silviculture, continued development along the coastal zone, and urban expansion. One of the key changes will be increased agricultural activity. Current and future world demand for agricultural products, especially for grain and oil seeds for animal feed, is expected to contribute to an estimated 59 percent growth in the U.S. agricultural earnings during the period 1978-2000.

Figure 1-5 shows the percent growth in agricultural earnings for each state for the period 1978-2000. All states in the study area are expected to increase their annual income from agriculture. In Region 4, Kentucky, Florida, and Georgia are projected to grow faster than the U.S; this is the case for all states of Region 6 with the exception of Arkansas. Much of this projected growth in agricultural earnings is based on the expectation that additional land will be devoted to crop production. The National Agricultural Lands Study (Hidlebaugh, 1980) reveals that over half of the 115 million acres of prime farmland potentially convertible to cropland in the U.S. is located in the Sunbelt. Most of this land is currently used as pasture, range, or forest.

These and related growth patterns will have a variety of benefits for the region and the nation. Regionally, per capita income is projected to increase and states which have lagged behind national averages for decades can expect rates of growth faster than the national average (see Chapter 3). Because of new jobs created by industrial growth, relatively low unemployment can be expected throughout the region. For example, in Oklahoma, average unemployment has been 5 percent or less during the past five years. Many

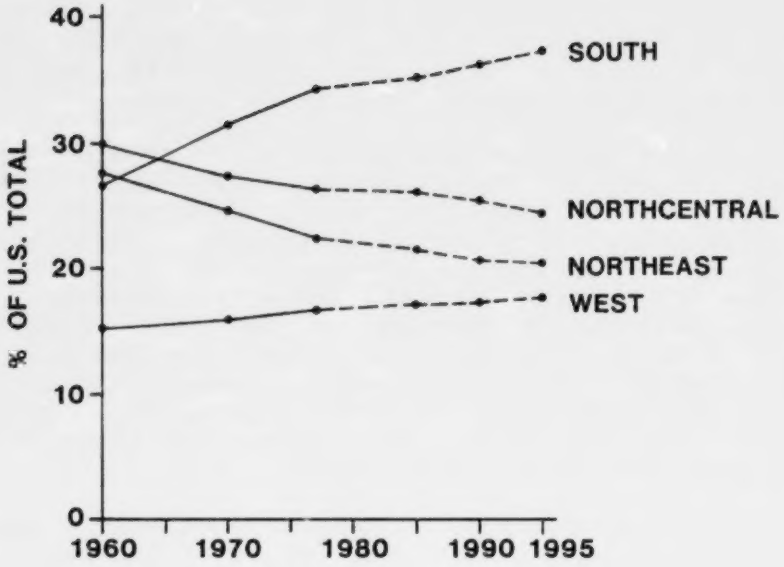


Figure 1-4: Consumptive Energy Use

Source: U.S., DOE, 1980; Galliker, 1979.

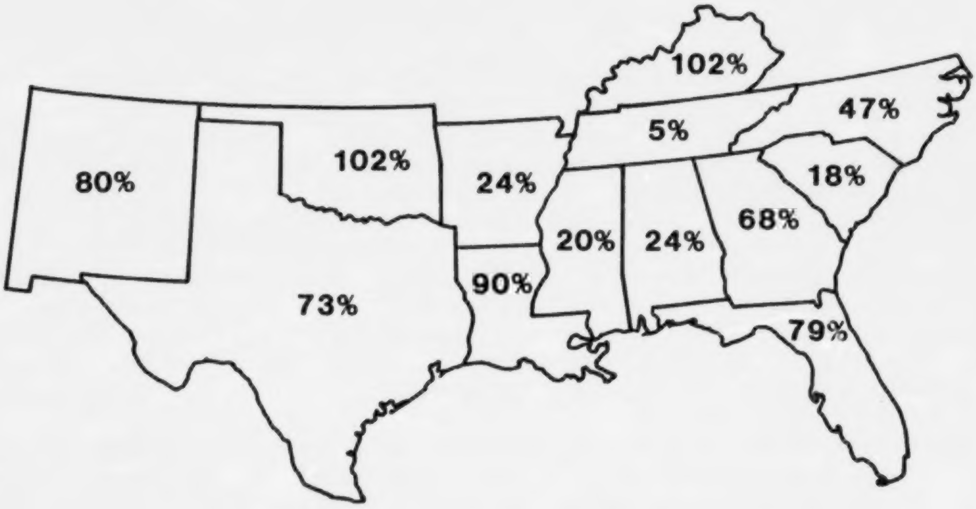


Figure 1-5: Growth of Agricultural Earnings (%): 1978-2010
(U.S. Average = 59% growth)

Source: Hidlebaugh, 1980.

communities will be able to provide improved public services as population and tax bases increase, and social and cultural activities will increase. All of these advantages help to create a positive outlook toward the future throughout most of the Sunbelt (see Chapter 5).

In addition, southern growth will provide national benefits. Several southern industries, such as chemicals and textiles, already are critical to the national economy and are expected to continue to grow in the future (see chapters 7 and 8). Such industrial growth stimulates subsidiary industries nationwide and helps to moderate price increases to consumers. U.S. balance of payments will be improved by increased export of agricultural commodities and, as domestic energy development grows, by decreased dependence on imported oil.

In addition to these benefits, the magnitude and rapid pace of growth in the Sunbelt will create several environmental and natural resource management concerns. For example:

- Conflicts over water availability and quality will increase throughout the 13 states. For example, energy development is rapidly increasing in an area of Texas already experiencing serious water problems;
- The South has an estimated 200,000 generators of hazardous wastes: immediate and latent problems associated with worker safety, transportation, and disposal will be aggravated;
- Approximately 50 percent of the total U.S. fish catch is landed in the study area; yet large fishing areas are being restricted by industrial and biological pollution;
- Energy facility siting issues could become more severe because of multiple developments, competition for resources with other industries, and difficulties associated with air quality regulations; and
- Concerns over appropriate land uses could increase, including problems created by expanded pesticide and herbicide use as range and forest lands are converted to croplands.

These and other impacts can create important local issues and could restrict growth in some areas. Thus, the most significant growth management issues need to be identified and options for balancing economic growth and environmental protection need to be addressed.

1.3 THE SOUTHERN REGIONAL ENVIRONMENTAL ASSESSMENT (SREA)

This Environmental Status Report is the first report of the SREA. The SREA is intended to be a three year project to assess the implications of growth in the South. As suggested in Table 1-1, the SREA is divided into two phases. Phase I essentially has been the design stage of the study, intended to integrate current information about growth in the South and to identify areas for further research in Phase II. Phase II is intended to provide detailed research on key growth related issues, including identification of high priority issues, evaluation of policy options, and identification of research needs. Phase II started September 1, 1981 and is intended to continue for two years. Elaboration of the activities of each phase is provided below.

The audiences for the SREA are primarily the EPA and state and local governments in the study area. For EPA, the SREA is intended to improve R&D planning and to inform program offices. For states, the study is intended to: (1) help provide an "early warning system" so that states can better anticipate future problems; and (2) provide technical assistance, for example, by identifying options for addressing key problems such as the siting of hazardous facilities or protecting ground water systems. In addition, the SREA is intended to inform other federal agencies and other stakeholders in the region, including business and industry.

1.3.1 Phase I

The first phase of the SREA has been largely devoted to integrating existing information in order to characterize the southern region. This includes identification of the causes of growth and change, characterization of key "driving forces" which create the benefits and concerns about growth, and characterization of the current status of environmental conditions related to air, water, and land resources. The primary product of this activity is this Environmental Status Report.

The Environmental Status Report serves two purposes. First, it is intended to be a broad reference document about southern growth. Although it does contain specific information such as current "hotspots," important problems, and regulatory deficiencies, its more general goal is the synthesis and integration of existing information to provide a broad overview of the region. Such an overview provides a picture of the current status of the 13 states and suggests how the region is likely to develop in the future. Thus, by itself, this report is not intended to evaluate or suggest policies for managing growth or improving regulatory policy.

The second purpose of the Environmental Status Report is to begin to establish a research agenda for Phase II of the SREA.

TABLE 1-1: THE SOUTHERN REGIONAL ENVIRONMENTAL ASSESSMENT

Phase	Time	Purposes
Phase I	October, 1980- August, 1981	• Identify current trends and future patterns in the South • Integrate existing information on environmentAL problems and growth management issues
Phase II	September, 1981- August, 1983	• Identify high priority problems related to southern growth • Identify and evaluate policy options for the most serious problems • Identify data and research needs for responding to future environmental concerns

That is, given a general understanding of growth in the region, the next step is to select particular geographic areas, environmental concerns, or driving forces which reflect high priority concern in the region. Each chapter of volumes II and III of this study attempts to identify the most significant concerns which should receive further attention.

To produce the Environmental Status Report, we have relied primarily on existing research products and data bases. These include EPA research products, growth profiles from each of the state governments, and the most recent growth projections from the U.S. Department of Commerce's Bureau of Economic Analysis. These information sources have been supplemented by our interaction with several regional and local groups--including regional EPA offices, EPA labs and research centers, the Tennessee Valley Authority, the Southern Growth Policies Board, and state agencies such as the Texas Energy and Natural Resources Advisory Council.

1.3.2 Phase II

Phase II is intended to provide policy-relevant information to the audiences of the study. Given the complexity of the study, no single model or technique is appropriate for meeting the goals of the study. Rather, several approaches and methodologies will be used at the following levels of analysis:

- Broad overviews to characterize region-wide trends and policy issues; we will continue to expand and update the information presented in this report;

- Region-wide studies which focus on critical driving forces and/or environmental concerns that cut across several parts of the study area; and

- Site-specific studies which provide detailed and integrated analysis of driving forces, environmental problems, and social/institutional structures within a localized geographical area.

Several criteria will be used to select key region-wide topics for study. These include: (1) is the topic widespread or pervasive throughout the study area? (2) how economically important is the topic? (3) are current policies and institutions inadequate to deal with future issues? and (4) are potential problems likely to require multi-state, regional, or federal responses rather than state or local responses? Potential topics which satisfy these criteria are:

- Availability and quality of water supplies;

- Accommodating growth of the chemical industry; and

- Siting of hazardous facilities.

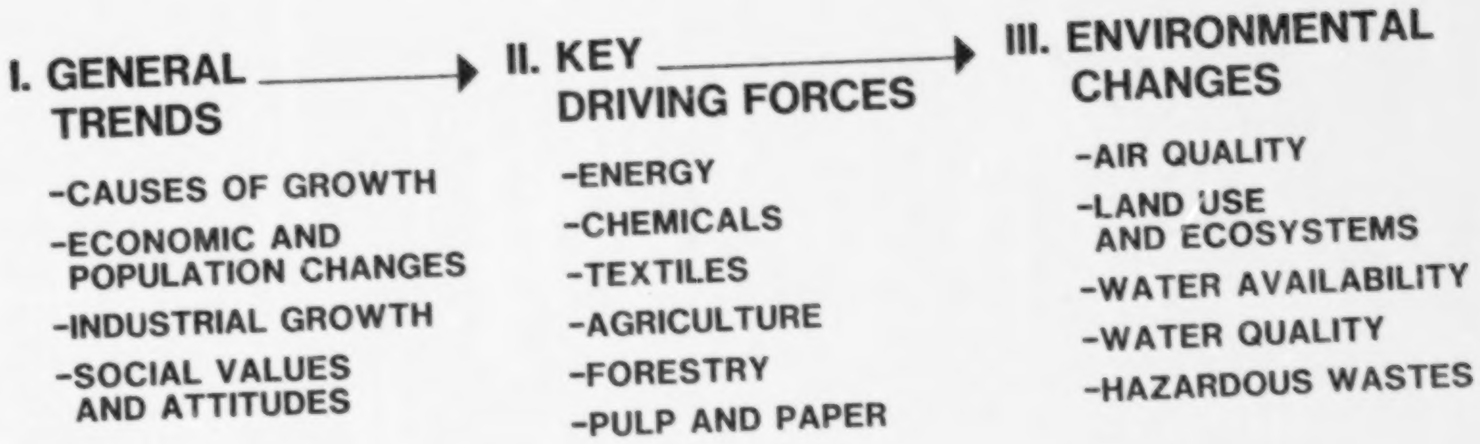
Several criteria will be used to select site-specific studies in which the scope is narrowed to a relatively small geographic area. These include: (1) the set of sites should be representative of key driving forces, environmental problems, and diverse geographical regions of the study area; (2) they should involve high-priority environmental/economic growth concerns--either immediate "hot spots" or areas facing pressures which could create important issues in the future; and (3) the sites should reflect local and regional concerns--they will be selected in consultation with EPA regional offices and state and local officials. As one example, work has begun on studying growth of the Mobile Bay area, which is representative of coastal areas which are important for fishing, tourism, and recreation and are also experiencing industrialization.

1.4 ORGANIZATION OF THE ENVIRONMENTAL STATUS REPORT

As discussed in the beginning of this chapter, the purpose of the Environmental Status Report is to link driving forces which create environmental change with the most significant current and future environmental concerns in the study area. The fifteen chapters of the Status Report are divided into three volumes. As suggested in Figure 1-6, Volume I discusses general trends contributing to the Sunbelt phenomenon. Chapter 1 introduces the study and describes general patterns of growth and change in the study area; Chapter 2 identifies the range of factors important to growth; Chapter 3 discusses economic and population changes; Chapter 4 describes industrial trends; and Chapter 5 characterizes social values and attitudes.

Volume II provides more detailed discussion of trends in economic development. Chapter 6 describes energy production and consumption, including trends in oil and gas development, coal, synthetic fuels, biomass, nuclear, and geothermal; chapters 7 and 8 discuss the chemical and textile industries; Chapter 9 characterizes agricultural and forestry production; and Chapter 10 discusses the pulp and paper industry.

Volume III is concerned with five environmental categories in the study area: air quality (Chapter 11); land and coastal zone use (Chapter 12); water availability (Chapter 13); water quality (Chapter 14); and hazardous wastes (Chapter 15). Each chapter links the problem category to one or more of the driving forces identified in Volume II and discusses current conditions and possible future trends.



I. GENERAL TRENDS → II. KEY DRIVING FORCES → III. ENVIRONMENTAL CHANGES

I. GENERAL TRENDS

-CAUSES OF GROWTH
-ECONOMIC AND POPULATION CHANGES
-INDUSTRIAL GROWTH
-SOCIAL VALUES AND ATTITUDES

II. KEY DRIVING FORCES

-ENERGY
-CHEMICALS
-TEXTILES
-AGRICULTURE
-FORESTRY
-PULP AND PAPER

III. ENVIRONMENTAL CHANGES

-AIR QUALITY
-LAND USE AND ECOSYSTEMS
-WATER AVAILABILITY
-WATER QUALITY
-HAZARDOUS WASTES

Figure 1-6: Organization of the Environmental Status Report

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CHAPTER 2

GROWTH AND CHANGE IN THE SUNBELT

HIGHLIGHTS

1. The growth rate of total employment never exceeded 16 percent prior to 1960 but accelerated sharply after that. Total employment grew 23 percent from 1960 to 1969 and 43 percent from 1970 to 1975.

2. This sudden acceleration largely results from underlying trends evident in the South since at least 1920:

   - Farm employment in the South declined precipitously after 1920 and did not begin to level out until after 1960.

   - Manufacturing employment has experienced a steady rise of 20 to 40 percent per decade since 1920, with the exception of the Great Depression years.

3. Much of the industrial growth of the South can be attributed to lower wages and a labor management environment favorable to industry:

   - In 1969 median wage income in the South typically ranged between 80 and 90 percent of U.S. values for comparable occupations. Specific comparisons are often even greater. For example, in 1973 average employee compensation per hour in the South in the cotton textile industry was 63 percent of that in the Northeast.

   - Labor union membership as a percentage of total employment in all Sunbelt states is below the U.S. value of 24 percent.

4. The South has been a region of abundant, low-cost energy. In 1974, Texas, Louisiana, and Oklahoma produced 68 percent of the crude oil and 76 percent of the natural gas. Average prices to industrial users for electricity, natural gas, and residual fuel oil are well below national averages in Region 6. Compared to the industrial Northeast, prices in both regions 4 and 6 for all fuels but coal are very favorable.

5. The South also possesses other important resources that have facilitated industrial growth:

   - Rich agricultural regions that produce large quantities of produce requiring processing;

   - Extensive forest resources that have attracted a significant portion of the nations pulp and paper industry;

   - Petroleum resources that serve as feedstocks for petroleum refining and the chemical industry; and

   - Relatively abundant and unpolluted water and air resources.

6. Since World War II, improvements in transportation facilities, particularly highways, have increased the accessibility of the South. Studies of firms locating in the South today indicate the availability of transportation to be a major criterion in their choice.

7. For a number of decades federal spending in the South has exceeded federal taxes collected in the South, creating an important stimulant to the southern economy. Although the ratio of spending to taxes in the South has been declining recently, in 1979 these inbalances created a net inflow of 16 billion dollars to the South.

8. Growth in the South is becoming increasingly self-sustaining because of growth in the size of the regional market and because industrial growth often attracts additional growth in the same or related industries. With the projected decline of regional difference in other variables important to growth, the size of the market and the existence of additional economies to industrial concentration are likely to become increasingly important determinants of southern growth.

9. In spite of the general perception that low business taxes have contributed to the favorable business climate of the South, most research indicates low business taxes and tax incentives have not played a significant role in industrial location in the nation as a whole or in the South, although they may have had a small effect on the growth of individual states or localities within the Sunbelt. Other variables, such as labor and transportation costs, vary much more than taxes among regions and so play a much more significant role.

10. A region may also grow by attracting people--in fact, the amenities of a region may be more important to the growth of a region than its attractiveness to industry. The most enduring amenities of the South include the mild winters and the landscapes and recreational opportunities provided by the oceans, beaches, mountains, streams, and natural and man-made lakes.

CHAPTER 2

GROWTH AND CHANGE IN THE SUNBELT

2.1 INTRODUCTION

Regional growth often creates the potential for environmental change. Population growth increases the need for land and a pure water supply and increases the volume of generated waste materials such as automobile exhaust, sewage, and solid waste. Economic growth, particularly industrial growth, typically increases the input of raw materials and the output of waste materials, many of which have environmental and human health consequences. Per capita income growth typically increases the consumption of goods and services, increasing the problems associated with population growth and fueling further economic growth. Growth can also provide an environmental benefit by raising concerns and revenues required to improve environmental quality.

During the first half of this century, the South was a relatively rural region with a small industrial base. As Figure 2-1 shows, population and economic growth rates and per capita incomes were below United States averages. During the past decade, the centers of economic, population, and per capita income growth in the United States have shifted from the North to the South and West. As a result of such growth, the focus of environmental concern has expanded to include the South. From 1970 to 1978, the population growth rate in the South was over one and one-half times the growth rate of the U.S. and the growth rate of employment was twice as great. Per capita incomes in the Sunbelt are rapidly approaching those of the U.S.

Chapters 3 and 4 describe in more detail current and projected trends in southern population and economic growth. This chapter examines the causes of population and economic growth in the South to date. Considerable controversy surrounds almost all interpretations of regional growth. Some assert that economic growth is the primary determinant of migration and population growth, while others argue that migration and population growth are most important. A more widely held view is that migration, population growth, and economic development are a jointly dependent, circular process. Economic growth draws people and population growth provides the markets and the labor supply for further economic growth. Thus, this chapter is divided into two major sections. The first examines those characteristics of the

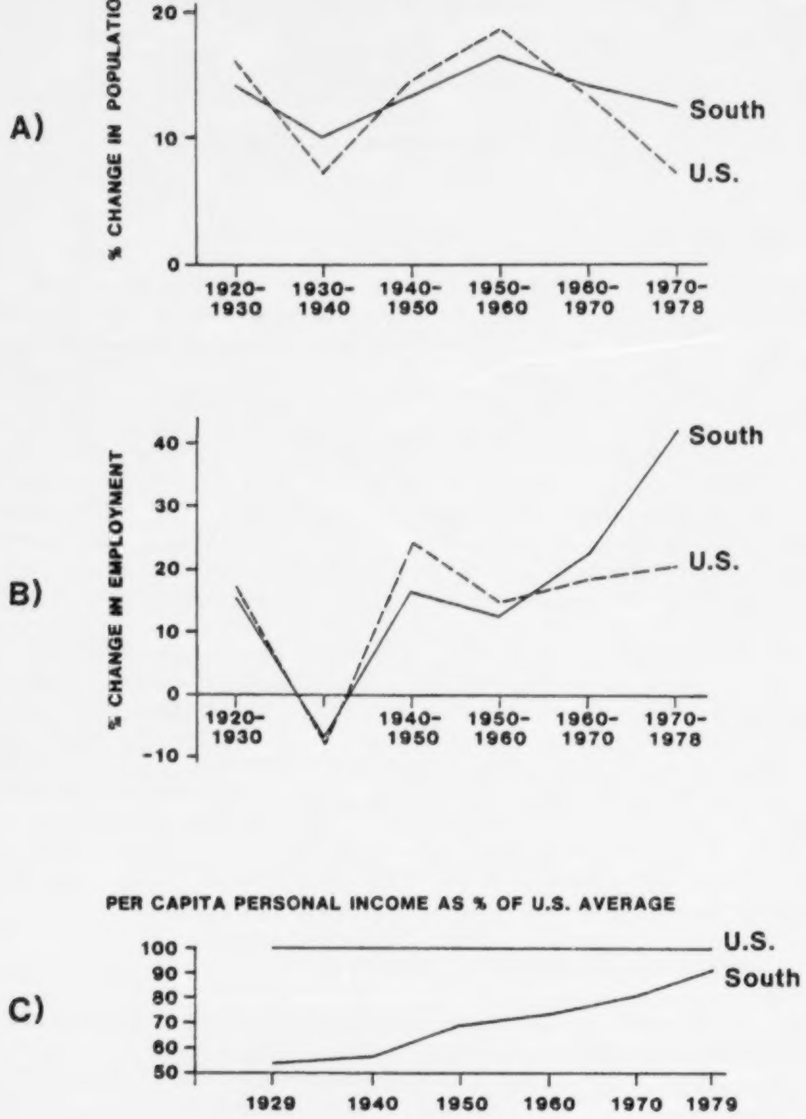

Figure 2-1: (a) Population Growth Rate, (b) Employment Growth Rate, and (c) Per Capita Income for the South and Nonsouth.

Source: U.S., Dept. of Commerce, Bur. of Census, 1920-1970; and U.S., Dept. of Commerce, BEA, 1980.

South that encourage economic growth and the second those characteristics that attract people.

2.2 CHARACTERISTICS ENCOURAGING ECONOMIC GROWTH

2.2.1 The Importance of Manufacturing

As shown in Figure 2-1, total employment in the South grew relatively slowly between 1920 and 1960, with employment growth rates never exceeding 16 percent per decade. However, beginning around 1960 the employment growth rate accelerated. The growth rate increased to 23 percent during the 1960's and to 43 percent from 1970 to 1975. To a large extent, this sudden acceleration is a result of underlying trends that have been building since at least 1920.

These trends become evident when changes in the structure of the southern economy are examined. Basic industries, or those sectors that serve national markets, form the economic foundation of a region. They are typically defined to include a high proportion of agriculture, mining, and manufacturing plus portions of other major sectors. Remaining sectors, termed service or nonbasic, serve primarily regional markets and depend for their growth on growth in the region's basic sector. Generally they are locationally tied to the industries and population they serve. These sectors typically include most government, services, finance, insurance and real estate, retail and wholesale trade, transportation, utilities, and construction.[1] The size of the nonbasic sector, relative to the basic sector, is dependent on the proportion of revenues producers spend on services and on the wages paid to employees in basic industries. Where service inputs to basic industries and employee incomes are high, spending for services is high and the nonbasic sector increases its importance in the total economy. Trends in total employment are thus related to the success of a region in attracting basic industries and the wages paid by the basic sector.

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[1] With continuing improvements in communication, transportation, and information processing technology, the traditional division between basic and nonbasic service industries is blurring. Some service industries are increasingly able to serve customers at considerable distances. As this happens, these industries move from the nonbasic to the basic sector.

In 1920, agricultural employment dominated both basic and total employment in the South,[1] representing 69 percent of basic employment and 47 percent of nonbasic employment (Table 2-1). Only 27 percent of basic and 19 percent of nonbasic employment was in manufacturing. For the rest of the country in 1920, the roles of agricultural and manufacturing employment were almost exactly reversed; manufacturing had increased to account for 64 percent of basic employment compared to only 31 percent for agriculture.

The agricultural sector thus remained preeminent in the economy of the South longer than in the rest of the country. Numerous reasons have been identified for the relatively underdeveloped status of the South, including:

- The cumulative headstart in the North;
- Inadequate transportation and discriminatory railroad rates;
- A poorly developed urban network;
- The dominance of cotton and the sharecropper system;
- A colonial pattern of absentee ownership of resources;
- The destruction and political aftermath of the civil war;
- A poorly educated labor force;
- An unequal distribution of income; and
- Overt racial discrimination.

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[1] Because of the availability of data, statistics presented in this chapter for the South are based on the regions as defined by the Census Bureau, unless otherwise indicated. The South Atlantic Region includes Maryland, Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida. The East Southcentral Region includes Kentucky, Tennessee, Mississippi, and Alabama. The West Southcentral Region includes Arkansas, Louisiana, Oklahoma, and Texas. The South by this definition differs from the study area defined for this report through the inclusion of Maryland, Delaware, Virginia, West Virginia, and Washington, D.C., and the exclusion of New Mexico. This definition tends to underestimate differences between the study area and the rest of the nation.

TABLE 2-1: STRUCTURE OF EMPLOYMENT IN THE SOUTH AND NONSOUTH, 1920

Sector	Percent of Basic Employment		Percent of Total Employment	
	South[a]	Nonsouth	South	Nonsouth
Agriculture	69	31	47	18
Mining	4	5	3	3
Manufacturing	27	64	19	36
Total	100	100	69	57

Source: U.S., Dept. of Commerce, Bur. of Census, 1920.

[a] See footnote 1 on page 2-4.

Despite speculation over the reasons for the initial developmental lag, three trends have been evident since 1920[1] which together largely explain the slow economic growth from 1920 to 1960 followed by rapid economic growth from 1960-1978 (Figure 2-2). In in the 1920's, agricultural employment in the South declined precipitously, influenced by the fall of cotton prices, the decline of the sharecropping system and the technological and economic changes leading to farm consolidation throughout the nation. Until 1960, this decline in agricultural employment was not entirely offset by increases in manufacturing employment. Thus, total basic employment actually fell during every decade between 1930 and 1960. The decline in basic employment ensured that total employment could only rise slowly over the period, dependent on rising per capita incomes to generate sufficient growth in the service sector. As a result of this slow employment growth, most of the South experienced substantial outmigration over this period.

Although increases were not sufficient to offset decreases in agricultural employment, manufacturing employment in the South has experienced a steady rise of 20 to 40 percent per decade throughout the 1920 to 1970 period, with the exception of the depression years when manufacturing employment declined. Since 1970, however, the growth rate has declined slightly. Thus, the increase in manufacturing capacity in the South is a trend of long duration, but not until 1960 was the increase enough to

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[1] Detailed industry employment data were first collected by the census in 1920.

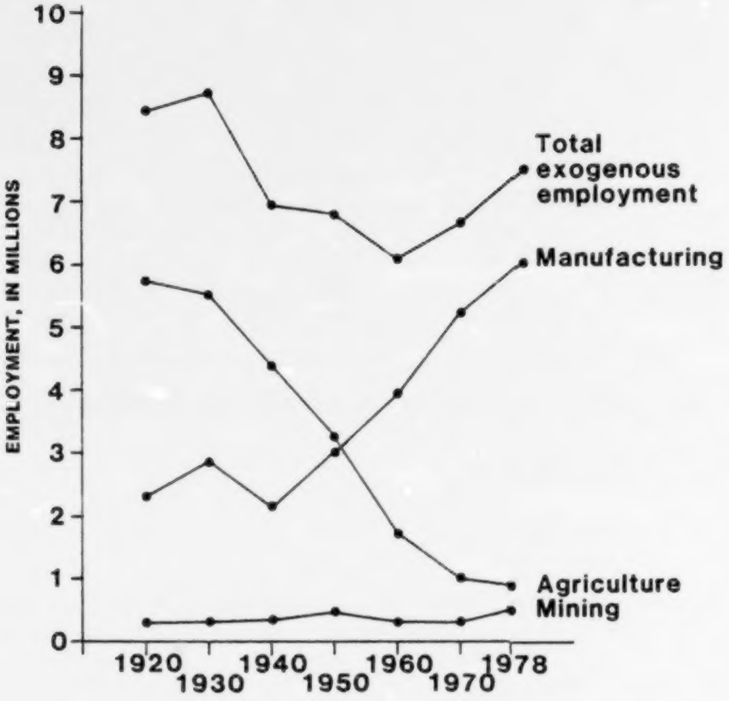

Figure 2-2: Employment in Basic Industries in the South, 1920-1980

Source: U.S., Dept. of Commerce, Bur. of Census, 1920-1970; and U.S., Dept. of Commerce BEA, 1980.

offset agricultural employment decline and to produce an increase in basic employment. Total employment growth began to accelerate at the same time that basic employment began to increase.

The third important trend is the rise in the percentage of total employment, that is, in the nonbasic, or service, sector. This percentage rose gradually from 32 percent in 1920 to 77 percent in 1978. The increase has been influenced by rising per capita incomes in the basic sector in the South attributable, at least in part, to:

- Increased productivity throughout the basic sector;

- A rising ratio of manufacturing employment to agricultural employment in the basic sector; and

- A rising ratio of high wage to low wage industries within the manufacturing sector.

The ability of the South to attract manufacturing has been central to its economic growth over the past 60 years. However, the recent acceleration of economic growth is not a result of recent change in the growth rate of manufacturing. The problem of evaluating the causes of recent economic growth in the South and the likelihood of its continuing, therefore, becomes a problem of determining why the South has been attracting manufacturing throughout this century and the probability that these reasons will continue to exist. The rest of this section discusses the competitive advantages of the South in attracting manufacturing, including: (1) resource cost and availability; (2) the development of agglomeration economies, transportation, and markets; and (3) governmental policies. Although the relative importance of these various advantages is ambiguous, these factors are generally considered to contribute to the region's attractiveness.

2.2.2 Resource Cost and Availability

The availability and cost of resources are important considerations in the location of most manufacturing activities. The South possesses advantages in the provision of certain important resources, including labor, energy, raw materials, and environmental resources.

A. Labor Cost and Availability

Lower labor costs are widely considered to be one of the most, if not the most, important reasons for the continued expansion of manufacturing in the South, especially when labor costs are considered as a combination of wage rates, the strength and activity of unions, and the availability and productivity of labor. The importance of this variable stems from the fact that labor is the single most costly input into manufacturing; about 50 percent of the value added in manufacturing is spent on payroll, two-thirds of which goes to production workers (Vaughan, 1979).

In the South, wages for comparable skill levels have been significantly below United States averages. As Table 2-2 indicates, median wage income in the South in 1969 typically ranged between 80 and 90 percent of U.S. values for comparable occupations. In given industries the differences can be even greater. In 1973, for example, average employee compensation per hour in the South in the cotton textile industry was 63 percent of that

TABLE 2-2: MEDIAN WAGE OR SALARY INCOME FOR MALES, 1969

Occupation	United States	South	South as percent of U.S.
Professionals, technical, and kindred workers	$11,752	$11,053	.940
Managers and administrators, except farm	11,747	10,427	.888
Sales workers	9,454	8,533	.902
Clerical and kindred workers	7,973	7,406	.929
Craftsmen and kindred workers	8,730	7,536	.863
Operatives, except transport	7,439	6,148	.826
Transport equipment operatives	7,583	6,074	.800
Laborers, except farm	6,135	4,721	.770
Farmers and farm managers	5,122	4,049	.790
Farm laborers and foremen	3,628	3,096	.853
Service workers, except private household	6,381	5,224	.819
Private household workers	3,118	2,247	.721
Total	8,517	7,365	.865

Source: U.S., Dept. of Commerce, Bur. of Census, 1973, Tables 227 and 296.

in the Northeast (McKenzie, 1979, p. 40). The supply of labor in the South at these wage levels, particularly unskilled labor, has been plentiful in the past. Employment to population ratios have been very low because of the excess supply of displaced agricultural employment.

Regional differences in wage rates and labor supply have been declining, however. In several highly skilled occupations, wage rates in the South are as high as or even slightly higher than in the North. But wage rates for most occupations, particularly blue collar and unskilled occupations, are still below national averages and are projected to remain below these values for a number of years to come. Employment to population ratios also have been approaching U.S. averages in many southern states, with the result that labor is no longer in excess supply in many areas. Greater tightness in labor markets may increase the upward pressure on wages and thus decrease the attractiveness of these areas to industry.

The extent of labor-management conflict can also significantly affect overall labor costs. A number of indicators confirm the general perception that labor-management relationships are more favorable to industry in the South. Labor union membership as a percentage of total employment is much lower in most southern states than in the nation (Table 2-3). Membership in all

TABLE 2-3: LABOR UNION MEMBERSHIP AS A PERCENT OF NONAGRICULTURAL EMPLOYMENT, 1978

State	Percent of Employment
Alabama	19
Arkansas	15
Florida	12
Georgia	14
Kentucky	23
Louisiana	16
Mississippi	13
New Mexico	12
North Carolina	7
Oklahoma	14
South Carolina	7
Tennessee	18
Texas	11
U.S.	24

Source: U.S., Dept. of Commerce, Bur. of Census, 1980, p. 429.

southern states is below the U.S. value of 24 percent. Only Kentucky (23 percent), Tennessee (18 percent), and Alabama (19 percent) approach the U.S. value and two states, North Carolina and South Carolina, have only 7 percent of their workforce unionized. Right-to-work laws in all study area states except Kentucky, Oklahoma, and New Mexico make it more difficult for unions to grow; very few of the industrialized states of the Northeast, Middle Atlantic, East Northcentral, or Pacific have such laws. Days idled due to work stoppages in most southern states are also well below U.S. averages (Table 2-4). The number of days idle per nonagricultural employee in 1978 was well below the U.S. average (0.43) for all study area states except Kentucky (1.73), Tennessee (0.43), Alabama (0.80) and New Mexico (0.50), states showing the influence of a high frequency of work stoppage in the coal mining industry. No other Sunbelt state has a value above 0.26, and idle days are particularly infrequent in the South Atlantic states of North Carolina (0.05), South Carolina (0.06), Georgia (0.10), and Florida (0.07). Unions are making inroads in the South, especially through the migration of union members and unionized industries, but clear differences between the South and the rest of the nation remain, and are projected to continue to remain.

TABLE 2-4: DAYS IDLED DUE TO WORK STOPPAGES PER NONAGRICULTURAL EMPLOYEE, 1978

State	Days Idled per Employee
Alabama	0.80
Arkansas	0.17
Florida	0.07
Georgia	0.10
Kentucky	1.73
Louisiana	0.16
Mississippi	0.25
New Mexico	0.50
North Carolina	0.05
Oklahoma	0.26
South Carolina	0.06
Tennessee	0.43
Texas	0.12

Source: U.S., Dept. of Commerce, Bur. of Census, 1980, pp. 412 and 431.

Labor cost is also affected by worker skill levels and productivity. Evidence based on the occupational mix and value added per worker indicate that both skill levels and productivity in the South were well below U.S. averages for the first half of this century, but that both have been increasing more rapidly in the South than in the U.S. (Horiba and Kirkpatrick, 1979; Singlemann, 1981; Toal, 1976). As a result, both occupational levels and value added per worker are now above the U.S. average in the West Southcentral Region and only slightly below U.S. averages in the South Atlantic and East Southcentral regions. These indicators are not good measures of the inherent abilities of the southern worker because they depend on the occupations offered by industry, the mix of industrial sectors, and the amount of other inputs, particularly capital, used in the production process. Other evidence indicates that although educational and skill levels of the southern labor force were low early in the century, improved education, state and industrial training programs, and labor force migration has significantly improved the quality of the labor force available in the South. A number of studies indicate that where other resources, including capital and management, are supplied in the same quantities, southern labor is as efficient as nonsouthern labor (Watkins, 1980).

Much of the evidence for the importance of labor costs to the growth of manufacturing in the South has been based on the geographic pattern of production for certain industries and products (Malecki, 1981; Rees, 1979a; Hekman, 1980; Hansen, forthcoming; Cromley and Leinbach, 1981). A product tends to progress through three stages during its life cycle. During the first stage, innovation, new products are developed. The location of such activities tends to be concentrated in the largest industrialized urban centers where interindustry linkages are strong, research and educational facilities are concentrated, and information networks meet. The cultural amenities of such regions are important to attracting the technical and professional skills required. The quality of these inputs is frequently more important than their price. The second, or growth, stage is characterized by the introduction of mass production. As a product passes through this stage, the input of technical, managerial, and professional skills decreases and production labor costs become increasingly significant. The third, or mature, stage is characterized by little innovation and long, routine production runs. Wages and the availability of relatively low skilled workers willing to accept lay-offs and flexible hours becomes a primary locational consideration. The manufacture of products in this stage tends to gravitate toward low wage areas, both foreign and domestic. Manufacturing establishments in this stage are frequently branch plants of larger firms that maintain their corporate headquarters and innovative capacity in other areas.

Much of the early growth in southern manufacturing consisted of mature industries, where labor costs dominated other locational considerations. Textiles and apparel manufacture, leaders in the industrial revolution and some of the first to reach the mature stage, moved much of their domestic capacity to the South in the first half of the 20th century in search of low labor costs that could compete with foreign production. These industries are still growing slowly in the South at a time when total production in the nation is declining. Many observers attribute the recent growth in the South of manufacturing capacity in other manufacturing sectors, many of which are still growing and developing new products, to the location by these industries of production capacity for established second and third stage products in lower wage areas. This view is supported by the high percentage of southern employment growth accounted for by branch plants. For example, Cromley and Leinbach (1981) found that in 1980 branch plants accounted for 79 percent of total manufacturing employment in Kentucky. In the high growth, innovative instruments, electronics, and computing equipment industries, most corporate headquarters and research and development facilities remain in the established centers of the Northeast and California, while the South is prominent in the mass production of products in these industries (Malecki, 1981; Hekman, 1980).

Other strong evidence exists for the importance of labor costs in the growth of manufacturing in the South. Carlton (1979) found in a national study that, after controlling for other variables important to industrial location, labor costs were the most significant determinant of employment growth in the plastics, communication transmission equipment, and electronic components industries. In a survey of 23 studies in which company executives of newly established plants were asked to name important determinants of their locational choice, 16 out of the 23 studies found that labor costs were a primary determinant (Moriarty et al., 1980). A South Carolina study found that in executives' remarks made "on-the-record," low wages and the abscence of significant union activity were much less important than other reasons. In remarks considered "off-the-record," however, these reasons were at the top of the list (McKenzie, 1979, p. 45). An executive of Fantus Corporation, a plant location consulting firm, stated that "nine out of ten times you can hang it on labor costs and unionization" (Watkins, 1980).

In sum, a considerable consensus exists that attributes much of the industrial growth of the South to the ability of lower wages and a labor-management environment favorable to industry to attract production capacity for established products. As southern wages approach national levels and if regional differences in labor activism diminish, the ability of the South to attract as large a percentage of national growth in manufacturing as it has in recent years may decrease.

B. Energy Cost and Availability

The South has been a region of abundant, low-cost energy. In 1974, Texas and Louisiana combined produced 60 percent of the nation's crude oil and 70 percent of the natural gas (Hoch, 1980). Oklahoma produced another 8 percent of the crude, and Oklahoma and New Mexico each produced another 6 percent of the gas. Kentucky produced 24 percent of national coal production. These five states were large net exporters of energy, large enough to make the South as a whole a net exporter in spite of net imports by the other eight states in the study area (Boercker *et al.*, 1977). In addition, the area possessed 35 percent of the electrical generating capacity, 45 percent of the crude oil refining capacity, and 77 percent of the natural gas processing plants, and a good to very good pipeline distribution system (Brunson and Bever, 1977, p. 38). As Table 2-5 indicates, the South also possessed considerable price advantages in most fuels. Average retail prices to industrial users for electricity, natural gas, and residual fuel oil were well below national averages in Region 6, although prices in Region 4 more closely approximated national values. Compared to the industrialized Northeast, however, prices in both regions 4 and 6 were very favorable. For example, prices for all fuels except coal were well below those for Region 2 (New York and New Jersey) in both southern regions.

Energy prices and availability will continue to be favorable relative to other regions, although southern production as a percentage of the U.S. is expected to decline slightly and regional price levels will tend to converge. In 1980, the study area

TABLE 2-5: AVERAGE RETAIL PRICE OF ENERGY TO INDUSTRIAL USERS, 1980

	Dollars Per Million Btu's				
Region	Electricity	Natural Gas	Distillate	Residual Fuel Oil	Coal
Region 4	8.15	1.62	3.62	2.44	1.39
Region 6	7.23	1.18	3.65	2.24	1.74
Region 2[a]	10.53	2.77	3.77	2.50	1.48
U.S.	8.34	1.56	3.60	2.49	1.34

Source: U.S., DOE, EIA, 1980.

[a] New York and New Jersey.

possessed proved reserves equal to 43 percent of the nation's crude oil, 64 percent of the natural gas, 78 percent of the gas liquids, and 10 percent of coal expressed in Btu's (see Chapter 6). In addition, 52 percent of new electrical generating capacity to be built in the nation by 1990 is projected to be constructed in the South (U.S., DOE, EIA, 1980). The general pattern of relative prices evident in Table 2-5 is projected to continue, although regional differentials will tend to diminish with electricity prices in Region 6 and distillate prices in Region 4 experiencing particular gains (U.S., DOE, EIA, 1980).

Energy production can contribute to regional economic growth in two ways. Extraction activities themselves are a basic industry. Their impact on total regional economic activity depends on the size of the payroll, the extent to which other inputs such as equipment are purchased inside the region, and the extent to which the very large profits of recent years stay within the region. In general, the impact of these industries in the South is thought to be less substantial than the total value of output would indicate (Hoch, 1980; Pagoulatos and Anschel, 1981). Although wages in fossil fuel extraction have been high in recent years, payroll is a relatively small proportion of value added and, except in a few areas, total employment has been small. Other inputs are often imported and a large percentage of the profits accrue outside the region. The economic impact should not be minimized, however. Energy extraction activities have contributed very significantly to the economic base of such areas as eastern Kentucky; Houston and Dallas, Texas; New Orleans, Louisiana; and Tulsa, Oklahoma. The ability of extractive activities to sustain long-run growth is limited, however. Even though recent and projected future increases in extractive activities will continue to support economic growth, even boom conditions in certain areas of the South, most of these reserves have finite lifetimes. Depletion of fossil fuel reserves may create serious dislocations in the economies of localized areas in the near future (Pagoulatos and Anschel, 1981).

Energy extraction can also contribute to regional economic growth if its high availability and low price attracts manufacturing. In some industries, reliability of supply can be a more important consideration than price. There is considerable disagreement over the role abundant supplies and low prices in the South have had on manufacturing location. Because energy prices in general were low prior to the early 1970's, Miernyk (1977) believes southern energy advantages in both price and reliability of supply may have been important to only a few very energy-intensive industries not strongly tied to other localized inputs or markets, such as iron and steel production, aluminum and zinc refining, glass and chemical manufacture, and petroleum refining. Some evidence for the importance of energy costs in these industries is provided in Table 2-6. Growth rates for chemicals, primary metals, and stone, clay, and glass were substantially above national growth rates in the Sunbelt as a whole and especially in Region 6

TABLE 2-6: RATES OF GROWTH OF ENERGY-INTENSIVE INDUSTRIES[a] (percent change)

	Industry (SIC Code)					
	Chemicals (28)		Primary Metals (33)		Stone, Clay, and Glass (32)	
Region	1967-72	1972-77	1967-72	1972-77	1967-72	1972-77
Region 4	40	83	45	64	85	32
Region 6	63	137	29	85	63	56
Total	50	108	38	72	77	41
U.S.	38	74	21	60	51	49

Source: U.S., Dept. of Commerce, Industry and Trade Admin., 1980; U.S., Dept. of Commerce, Bur. of Census, 1976-78, 1979-80.

[a] Measured in terms of value-added, current dollars.

where most fossil fuel production occurs. Miernyk, for example, believes energy costs per dollar of value added were low enough in other industries that other locational variables were more important.

In contrast, both Hoch (1980) and Carlton (1979) believe energy prices, availability, and reliability of supply are more important in a wider range of industries than energy costs per dollar of value added indicate. Carlton found that energy prices and availability were a significant determinant in the location of the fabricated plastics and electronic components industries, where the ratios of energy expenditure to value added were very near the all industry average, 0.022 and 0.016, respectively. A clear relationship between the energy rich states and rapid growth in manufacturing and incomes has been noted by many observers (e.g., Hoch, 1980).

Many analysts agree differentials in energy prices and availability will become more important as energy prices increase in the future relative to other input prices (Rostow, 1977; Hoch, 1980; and Miernyk, 1977). Regional differences in prices, however, are projected to decline. The net affect of these opposing trends is difficult to project. Most probably, energy prices will continue to favor the location of energy intensive industries in the South for a number of years to come (Hoch, 1980);

but if prices converge and southern fossil fuels approach depletion, the advantage may disappear.

C. Other Raw Materials

The South possesses a number of raw material resources that have attracted manufacturing. Manufacturing sectors with strong raw material locational orientations include food processing, lumber products, pulp and paper, petroleum refining, certain chemicals, stone/clay/glass manufacture, and primary metals (Miernyk, 1977). Certain of these, including chemicals, petroleum refining, and primary metals, have more locational flexibility than others and also are sensitive to energy prices.

The South possesses resources essential to most of these industries. It is a rich agricultural region, with favorable soils, slopes, and climate. It produces a moderate to high percentage of total U.S. production of meat, sugarcane, soybeans, peanuts, and certain specialty crops such as fruits, vegetables, and tobacco--all of which result in significant food processing. The region has extensive forest resources; in 1977 they included 49 percent of the privately owned commercial timberland,[1] 39 percent of the nation's total commercial timberland, 28 percent of the growing stock by volume, and 23 percent of the sawtimber volume (U.S., Dept. of Commerce, Bur. of Census, 1980, p. 732). The lower percentages of growing stock and sawtimber relative to timberland reflect, at least in part, the specialization of the South in short rotation forest management for pulp rather than less productive or more poorly stocked forests. The considerable petroleum reserves of the region for petroleum refining and petrochemical production were discussed in the previous section. In 1978, New Mexico produced 10 percent of the nation's primary copper; Tennessee produced 29 percent of the zinc; and the Gulf states had excellent access to the Caribbean bauxite deposits as well as smaller deposits in Arkansas and Alabama (U.S., Dept. of Commerce, Bur. of Census, 1980).

Southern manufacturing has traditionally had a greater proportion of raw material oriented industries than has the United States as a whole. This reflects both the resource endowment of the region and the fact that in the past the South was in a poor competitive position to attract many industries not tied to immobile resources. As Table 2-7 indicates, in 1978 the South

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[1] Commercial timberland is forest land, in public or private ownership, capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands and not withdrawn by statute of regulation. Currently inaccessible or inoperable lands are excluded. See Chapter 9 for a more complete discussion.

TABLE 2-7: SUNBELT SHARE AND GROWTH OF RAW MATERIAL ORIENTED INDUSTRIES, 1978

Major Raw Material Oriented Sectors	Labor Earnings in South[a] (millions of 1972 dollars)	Percent of U.S. Earnings	Percent Change 1969-78	
			South	U.S.
Food Processing	3,944	23	3	12
Pulp and Paper	2,249	26	46	24
Chemicals	4,368	29	47	23
Petroleum Refining	1,319	36	54	41
Lumber Products	2,216	30	48	52
Stone, Clay, and Glass	1,849	23	53	34
Primary Metals	2,470	13	59	23
Total	18,415	23	--	--
All Manufacturing	47,823	21	39	18

Source: U.S., Dept. of Commerce, BEA, 1980.

[a] Regions 4 and 6.

produced a slightly larger share of U.S. earnings in the combined major raw material oriented sectors than it did in total manufacturing (23 vs 21 percent). In specific raw material sectors, however, it produced even larger shares--26 percent for pulp and paper, 29 percent for chemicals, 36 percent for petroleum refining, and 30 percent for lumber products. All the southern raw material oriented sectors except food processing have been growing more rapidly in the recent past than manufacturing as a whole, and all but food processing and lumber products have been growing more rapidly in the South than in the nation as a whole, typically about twice as fast (Table 2-7). These growth rates indicate that the raw material resources of the South will likely continue to contribute to significant manufacturing growth in the South. Domestic petroleum and metal resources which the chemicals, petroleum refining, and primary metals industries use are subject to depletion; but the current concentrations of these industries in areas with access to low cost water transportation and to major pipelines may allow these industries to maintain growth using foreign raw materials. The success of the aluminum refining industry along the Gulf Coast based on Caribbean bauxite is a case in point.

D. Environmental Resources

The South also possesses important environmental resources. While these resources cannot be considered to have been a major determinant of manufacturing growth in the South, they have facilitated growth, particularly in recent years as these resources have become more scarce in other industrial regions and as concern over environmental problems has increased.

Water resources are usually considered abundant throughout most of the eastern two-thirds of the Sunbelt. Both ground water and surface water resources are severely limited throughout much of New Mexico, Texas, and Oklahoma. Rainfall in these states averages 10 to 20 inches per year and is subject to high seasonal variability. In contrast, water is physically available and subject to relatively uniform annual flows throughout much of the Southeast. For this reason, many industries have been, and will continue to be, attracted to the South--including energy development, chemical manufacturing, pulp and paper, and primary metals production. However, the physical abundance of water will be affected by increasing water quality concerns in some areas, including much of the Gulf Coast, several areas along the Atlantic Coast, and large portions of Kentucky, Georgia, and Mississippi. The relationship between water quality and water availability will be increasingly important to the growth of the Sunbelt region (see chapters 13 and 14).

Air quality is generally good throughout the Sunbelt, especially in comparison with problems experienced in the more heavily industrialized regions of the United States. Growth and development has been facilitated in both the Southeast and Southwest by the relatively few Class I areas, requiring special protection under the Prevention of Significant Deterioration regulations, and the progress made in cleaning up nonattainment areas. In addition, new regulatory approaches such as the bubble concept and emissions offset programs have provided states such as Oklahoma, Texas, and Kentucky with more flexibility in attracting and locating industries.

However, the cumulative effects of rapid population growth and increasing urbanization, industrialization, and energy development in some areas of the Sunbelt are affecting local and regional efforts to maintain or improve air quality. Increasing emissions from mobile sources are a continuing problem in high growth nonattainment areas such as southern Florida, the Carolinas' Piedmont, the area surrounding Charlotte, North Carolina, Atlanta, Georgia, and the greater Houston area in Texas, while rapid industrial growth and energy development raises air quality concerns for areas such as the Gulf coast of Texas, parts of New Mexico, and the Appalachian areas of Kentucky and Tennessee. Overall, however, air quality issues in the Sunbelt are likely to focus on modification of siting and control strategies rather than on actual restrictions on growth and development (see Chapter 11). Thus, relatively high quality and abundant water and air resources have facilitated industrial growth in the South and are likely to continue to do so in the future.

2.2.3 Development of Regional Markets

Manufacturing location has become increasingly market oriented during the 20th century because of transportation improvements; scale economies and localized raw material depletion that limit the importance of individual raw material sites; the trend toward more highly processed products; and the increasing complexity of interindustry linkages. Sustained economic growth of a region therefore often depends on the development of large internal markets (Pluta, 1980; Moriarty et al., 1980). As the South's regional population and economy become the largest in the nation, the national market for basic industries is increasingly located inside the region. The region becomes more attractive to manufacturing and other industries. Transportation and other communication costs to markets are reduced. The region becomes less dependent on exports to other regions and less susceptible to competition from other regions in the effort to attract basic industry. As a result, regional growth becomes more self-sustaining, generating growth internally rather than capturing it at the expense of other regions.

The growth of the regional market has been very important to the growth of the Sunbelt and will become increasingly important as the region continues to grow and other advantages diminish. The importance of the market as a factor in industrial location in general, and present and future growth of the South in particular, is emphasized by many studies of both national and southern industrial locational decisions that have found access to markets to be a prime determinant of such decisions (Moriarty et al., 1980).

2.2.4 Transportation

Although transport costs are less important than they once were because of the decline in transportation costs relative to other inputs, they are still a major factor in the locational decisions of many industries, particularly those with bulky or low value inputs or products (Smith, 1971; Moriarty et al., 1980). Poor rail and highway transportation networks along with discriminatory rate structures have been widely cited as one of the hindrances to southern industrialization prior to World War II (Watkins and Perry, 1977; Serow, 1981).

Since World War II, however, improvements in transportation networks, often financed with federal funds, have increased the accessibility of the South. Studies of firms locating in the South today indicate the availability of transportation to be a major criterion in their choice of state or region (Moriarty *et al*., 1980). Federal highway construction since 1950, combined with the shift of most freight to the highways from the railroads, opened many areas of the South, especially nonmetropolitan areas, to manufacturing. For example, a study of industrial location in nonmetropolitan Kentucky found the presence of a limited access highway affected branch plant location (Cromley and Leinbach, 1981). Extensive port development, particularly along the Gulf Coast, has allowed cargo tonnage handled by these ports to increase dramatically. Waterborne imports and exports handled by Gulf ports increased by almost 600 percent between 1960 and 1979 in contrast to only 177 percent for the nation as a whole (U.S., Dept. of Commerce, Bur. of Census, 1980, p. 675). New Orleans, Houston, and Baton Rouge were the second, third, and fourth largest U.S. ports by tonnage handled in 1976 (Greene *et al*., 1978, p. 238). Extensive federal improvements to inland waterways, particularly to the Tennessee/Ohio/Mississippi system and to the Tombigbee system, have increased the accessibility of the basins they serve to low cost barge traffic. The connection of the port of Mobile on the Gulf Coast with the Tennessee River by the Tennessee-Tombigbee Waterway presently under construction will further improve the accessibility of the East Southcentral states. Airport construction has proceeded at a rapid pace in the South. Atlanta and Dallas/Ft. Worth have developed into major regional air hubs with excellent connections to the rest of the nation (Greene *et al*., 1978, pp. 169-70). Other major centers in the South include Houston, New Orleans, Tampa, and Miami. In 1975, Texas, Georgia, and Florida were among the leading six states in air carrier activity (Greene *et al*., 1978, pp. 169-70). In contrast to many other major airports throughout the nation which are projected to be near saturation by 1987, all major Sunbelt airports except Nashville Metro, Charlotte-Douglas Municipal, and Albuquerque International have considerable available capacity. Finally, the Texas/Louisiana/Oklahoma area remains the focus of the United States petroleum and natural gas pipeline distribution system, providing many Sunbelt states with good access to oil and gas for both fuel and raw material use (*Oxford Economic Atlas*, 1975).

2.2.5 Development of Agglomeration Economies

The geographic concentration of manufacturing plants can bring economic benefits which are impossible to obtain in more isolated locations. These benefits, or agglomeration economies, will continue to be important to the continued attractiveness of the South to industry. They contribute to a self-sustaining momentum; as more firms locate in an area they create additional agglomeration economies that attract additional firms. Such economies become increasingly important to regional industrial location as advantages in other costs, such as labor, diminish or become negative. Such development of agglomeration economies is considered by some authorities to be one of the prime determinants of regional growth (see Wheaton, 1979a, p. 7).

Agglomeration economies are of two major types--economies of localization, which arise from the concentration of related firms, and urbanization economies, which arise from the concentration of industrial activity in general. Economies of localization include savings in communication and transport costs when materials, products, contacts, and information flow between firms in the same or related industries. Other localization economies include the development of a trained pool of labor, specialized research and educational facilities, and specialized service industries such as equipment repair, component and container suppliers, and marketing organizations. Such economies attracted the textile machinery industry to the South on the heels of the textile industry itself and are responsible for the concentration of the petroleum exploration equipment manufacturing industry in the region. They are important to the location of firms in industrial complexes such as the traditional industrial core of primary metals, fabricated metals, machinery, and transportation equipment and to the petroleum refining/chemicals/plastics/synthetic textiles group of industries, all of which have grown rapidly in the South in recent years. Carlton (1979) found that the existing size of certain industries in a metropolitan area was a prime determinant of growth in those industries.

Urbanization economies generally arise from the availability of a large, high quality labor force and from the availability of infrastructure in larger cities or well integrated systems of cities. Such infrastructure includes transportation facilities, educational facilities, urban services such as water supply and treatment, sewers and waste management, and electrical utilities. Large economies of scale in the provision of these facilities, and their expense, emphasize the role of large cities, the states, and the federal government in their provision. It is generally agreed that the infrastructure available in the South prior to World War II was inadequate for wide-scale industrialization and that extensive improvements since then have been vital to the South's development (e.g., Watkins and Perry, 1977). Federal highway construction, port development, and other transportation improvements, as discussed previously, have been very important to the opening of the South.

The federal government has also taken a major role in the development of sewer capacity and electrical generating capacity, (e.g., the Tennessee Valley Authority). The increase in the population size, per capita income, and economic base of southern cities has allowed them increasingly to participate in the provision of these services. The development of an adequate infrastructural base is both time consuming and expensive, but it is also cumulative and has contributed significantly to the development of the South and its ability to sustain growth.

At some point, industrial cities and regions can reach sizes where costs of concentration exceed further agglomeration economies, after which such regions lose much of their attractiveness to further development. Concentration costs include the costs of congestion, higher land and labor prices, increasing labor organization and militancy, increasing costs to scale in the provision of infrastructure, and costs of meeting air quality standards. A common explanation for the northern decline in manufacturing in the face of rapid southern growth is a large difference between the two regions in the ratio of agglomeration economies to concentration costs (e.g., Mills, 1980). It is thought the costs of concentration in the larger metropolitan areas of the North and the need to replace the aging northern infrastructure and capital base make the North relatively unattractive to additional growth. In the South, in contrast, agglomeration economies have grown to the point where they are substantial and concentration costs are still low, creating a relatively favorable environment for growth. It is probable that the ratio of agglomeration economies to concentration costs in the South will remain favorable for some time in the future, thereby encouraging rapid growth. The length of this period will depend to some extent on the rate of investment in, and repair of, infrastructure and the success of the South in managing growth.

2.2.6 Development of an Innovative Capacity

As discussed previously, most of the growth in manufacturing capacity in the South has been growth in standardized production capacity for products developed elsewhere. Such growth is not associated with the same security and permanence as growth with a better balance of both innovative capacity and production capacity. Growth based on innovation is less susceptible to external control and to competition from low cost production regions. As some of the resource cost advantages of the South diminish, the innovative capacity of the South may become a more important determinant of growth. At the present time, innovative capacity continues to be highly concentrated in the large metropolitan areas of the North and California (Hekman, 1980; Rees, 1979a; Cohen, 1977; Malecki, 1980). The position of the South in 1976 was surveyed by Malecki (1980). Only Houston, Dallas/Ft. Worth, and Austin, Texas, and Huntsville, Alabama, ranked among the top twenty metropolitan areas on any of four measures of innovative capacity--number of industrial research and development labs, number of scientists and engineers, number of federally funded scientists and engineers, and university based research and development. When all measures were combined in one index standardized for population, the South fared slightly better; Tulsa, Oklahoma; Albuquerque, New Mexico; Knoxville, Tennessee; Orlando, Florida; and Raleigh-Durham, North Carolina, were added to the list. But still only 8 of the 44 Standard Metropolitan Statistical Areas (SMSAs) with a concentration of research and development (R&D) activity were located in the study area.

Authorities differ sharply over the ability of the South to develop a substantial innovative capacity. For example, Malecki and Cohen assert that recent growth in the Sunbelt in the high technology industries is primarily production capacity, with innovative functions still largely located elsewhere. Malecki notes that industrial R&D, the type of research and development most closely correlated with the development of new products, is very closely correlated with the location of the very largest metropolitan areas, most of which are located in the North and California. Federally funded research and development tends to dominate all of the previously noted R&D centers in the Sunbelt with the exception of Houston, Dallas/Ft. Worth, and Tulsa. Only in Huntsville, Austin, and Raleigh/Durham have federal facilities and universities attracted industrial research. With recent and expected future cutbacks in federally sponsored space and energy research, the prospects for continued strong research and development activity in Albuquerque, Knoxville, and Hunstville diminish. Thus, in this view, the long-run generation of a substantial innovative capacity in the South may be very slow in coming and depend on the extent to which Sunbelt metropolitan areas achieve premier rank within the nation in population, access to information, and quality educational institutions.

Norton and Rees (1979), Sale (1977), and Watkins and Perry (1977) are more optimistic. They point to the rapid growth in the South of the high technology electronics, computer, aerospace, instruments, chemicals, and plastics industries and increasing innovative functions. They hypothesize that spinoffs from federally funded R&D and the location of branch production plants in high technology industries can generate an innovative capability through the migration of technical personnel and entrepreneurs and the build up of agglomeration economies and regional demand. Rees (1979b) notes that the largest Sunbelt mettropolitan areas, Dallas/Ft. Worth and Houston, have managed to develop an innovative capacity as evidenced by the fact that most new manufacturing plants are new firms rather than branch plants and that most new branches are established by instate firms.

2.2.7 Governmental Policies

Accounts in the press of southern growth and northern stagnation have highlighted the role of governmental policies. Regional imbalances in the ratio of federal expenditures to federal revenues have become a source of regional conflict, leading to such accounts as the "Second War Between the States" (Business Week, 1976). State and local tax policies and incentive programs are widely perceived as having helped create a "favorable business climate" in southern states that have attracted industry. This section discusses the role of these policies in the growth of the South.

A. Federal Spending Policies

For a considerable time, the federal government has spent more money in the South and West than it has collected in tax revenue; the opposite has been the case for the Northeast and Midwest. In 1979, for example, the ratio of spending to taxes was 1.12 for the South and 1.05 for the West, but only 0.94 for the Northeast and 0.79 for the Midwest (Table 2-8). These imbalances created an inflow of 16 billion dollars to the South and an outflow of 34 billion dollars in the combined Northeast and Midwest. Within the South, most states have a net inflow of federal funds (Table 2-9). Alabama, Arkansas, Mississippi, Tennessee, and New Mexico had especially high spending to taxes ratios. The absolute inflow was greatest in Tennessee, Florida, New Mexico, Mississippi, and Alabama; only North Carolina and Texas experienced a net outflow. Geographic imbalances in the flow of federal funds have been generally declining over the past 30 years. For example, in 1952 the spending to taxes ratio was approximately 1.5 for the South as a whole and over 2.0 for selected states (Labovitz, 1978).

However, the favorable position of the South is, in part, a function of the fact that the federal income tax is progressive. Southerners have lower per capita incomes and therefore pay lower per capita taxes. In 1979, federal tax receipts per capita ranged from 63 percent of the national average in Mississippi to 101 percent in Texas (Tables 2-8 and 2-9). However, federal spending per capita, also tended to be low. Although not generally as small a proportion of the national average as for taxes, it was above the national average of 2,101 dollars in only three states--Florida, New Mexico, and Tennessee. The federal government spent less than 90 percent of the national per capita average in five southern states--Arkansas, Kentucky, Louisiana, North Carolina, and South Carolina. The fact that southern states have experienced a net inflow but at the same time have received below average per capita expenditures has generated a lively debate over the equity of the dollar flow imbalances (Haveman, Stanfield, and Pierce, 1976; Toal, 1977; Jusenius and Ledebur, 1977). Federal spending per capita in the South has been high in only a few categories (Peterson and Muller, 1980). Per capita defense salary expenditures and aerospace expenditures have been high in the South because of the large number of military bases and space program facilities in the South. Competitive bidding for a variety of goods purchased by the federal government has

TABLE 2-8: REGIONAL IMBALANCES IN FEDERAL SPENDING AND TAXES, 1979[a]

Location	Fiscal 1979			
	Spending Per Person	Taxes Per Person	Spending/ Taxes Ratio	Dollar Flow (in millions)
Northeast	$2,058	$2,200	$0.94	-$ 6,969
New England	2,399	2,145	1.09	2,390
Mid-Atlantic	1.964	2,219	0.88	-9,359
Midwest	1,738	2,202	0.79	-27,068
Great Lakes	1,609	2,275	0.71	-27,483
Great Plains	2,048	2,023	1.01	415
South	2,090	1,864	1.12	16,003
South Atlantic	2,188	1,908	1.15	9,596
South Central	1,997	1,822	1.10	6,407
West	2,348	2,240	1.05	4,403
Mountain	2,315	1,928	1.20	4,129
Pacific	2,359	2,350	1.00	274
Washington, D.C.	23,529	2,750	8.56	13,631
Total U.S.	$2,101	$2,101	$1.00	$0

Source: Data compiled from Havemann and Stanfield, 1981.

[a] The columns show: (1) federal spending per person; (2) the federal tax burden per person, with the federal deficit distributed as an added tax; (3) the amount of money received for each tax dollar; and (4) total funds that flowed in or out.

tended to favor the South's low production costs. Defense contracts have, on the whole, tended to favor the Northeast and the West, however. Grants-in-aid to state and local governments for public works and employment favored the South prior to the middle 1970s, but, after complaints by the North, formulas were changed to increase emphasis on the unemployment rate, thus favoring the North. Despite high per capita payments for retirement programs to Florida and high per capita welfare payments to the East Southcentral states, per capita transfer payments for the South as a whole are very near national averages.

An inflow of federal funds can operate to stimulate regional economic development in several ways. The purchase of goods from

TABLE 2-9: SOUTHERN STATE IMBALANCES IN FEDERAL SPENDING AND TAXES, 1979[a]

	Fiscal 1979			
Location	Spending Per Person	Taxes Per Person	Spending/ Taxes Ratio	Dollar Flow (in millions)
Alabama	$1,968	$1,595	$1.23	$1,406
Arkansas	1,815	1,464	1.24	766
Florida	2,217	1,999	1.11	1,934
Georgia	1,901	1,708	1.11	985
Kentucky	1,872	1,678	1.12	683
Louisiana	1,866	1,773	1.05	377
Mississippi	2,073	1,314	1.58	1,845
New Mexico	3,138	1,640	1.91	1,859
North Carolina	1,612	1,658	0.97	-262
Oklahoma	2,037	1,871	1.09	481
South Carolina	1,834	1,577	1.16	753
Tennessee	2,378	1,711	1.39	2,925
Texas	1,960	2,116	0.93	-2,075

Source: Data compiled from Havemann and Stanfield, 1981.

[a] The columns show: (1) federal spending per person; (2) the federal tax burden per person, with the federal deficit distributed as an added tax; (3) the amount of money received for each tax dollar; and (4) total funds that flowed in or out.

southern manufacturers encourages the location of industry in the South. The development of major aerospace facilities in the South has encouraged the development of high technology industry and may have contributed to the development of an increased southern innovative capacity. Salaries of federal employees and transfer payments add purchasing power to the southern market and are themselves as valuable a basic industry as any other. Grants-in-aid for public works have been vital to the development of an infrastructure attractive to industry. And direct federal construction of transportation facilities such as highways and inland waterways has contributed significantly to the ability of the South to attract transport oriented industry.

Although this net inflow of federal funds has been an important source of economic base in the South, observers differ over the magnitude of the effect and its importance to the growth of the Sunbelt. Richardson (1978, 1979, pp. 269-70), Sale (1977), and Watkins and Perry (1977) ascribe first-rate importance to the effect of federal spending. However, Peterson and Muller (1980) and Oakland (1979) are more cautious, emphasizing market forces and the complexity and flexibility of interregional patterns of production within a national economy unhampered by trade barriers. The probable effect of the projected declines in regional disparities in dollar flows as incomes rise in the South and spending formulas change will depend on the actual importance of inflows of federal funds in the past and the extent to which southern development has become self-sustaining.

B. State and Local Policies

1. State and Local Taxes

Many states and localities throughout the South and the nation as a whole believe that economic growth may bring substantial benefits and have developed policies and programs to attract industry. These programs are widely perceived by the public and public leaders to contribute to the favorable business climate of many areas of the country, including the Sunbelt (Boren, 1980; Padda, 1981). The actual effect of these policies is highly controversial. "Business climate" and many of the business-related policies and activities of government are very difficult to measure and therefore to include in statistical analyses of economic growth rates. Available evidence, however, indicates that three of the policies most widely included in the industrial development programs of Sunbelt states--tax incentives, financing incentives, and labor force training programs--may be less effective than is widely thought, although a definitive evaluation cannot be made on available evidence.

State and local taxes on industry in the South are generally below national averages and well below those in the Northeast. It is often argued these differences contribute strongly to the attractiveness of the South to industry. In 1976, state corporate income taxes on income over 25,000 dollars in the study area ranged from zero percent in Texas to 6 percent in Arkansas, Georgia, and the Carolinas (Moriarty et al., 1980, pp. 250-51). In contrast, 60 percent of the remaining states had rates of 7 percent or above, with New York, Connecticut, Minnesota, and Arizona having rates of 10 percent or above. Unemployment insurance rates in 1979 were an average 2.7 percent of payroll in the United States, but all study area states except Alabama and Louisiana had rates under 2.2 percent (U.S., Dept. of Commerce, Bur. of Census, 1980, p. 361). Local property taxes per capita ranged from 49 dollars in Alabama to 171 dollars in Texas. Except for Texas, each southern state ranked in the lower half of all states (Moriarty et al., 1980, pp. 250-51). In contrast, per capita property taxes in Connecticut, Massachusetts, New Jersey, and New York were above 330 dollars.

Tax incentives for new and expanding businesses are widely offered by states and localities in an attempt to attract industry. They include corporate income tax and property tax exemptions for specified time periods, excise tax and sales tax exemptions, tax exemptions on raw materials used in manufacturing, and investment tax credits. Each state in the U.S. provides some combination of these incentives. Although individual Sunbelt states, such as Alabama, provide a great variety of exemptions, Sunbelt states as a whole do not tend to provide more exemptions than nonsouthern states (Vaughn, 1979, pp. 96-97).

In spite of the general perception that low taxes and tax incentives attract industry, the consensus among researchers, with a few exceptions, is that such business tax advantages have not played a significant role in industrial location in general or the growth of the Sunbelt in particular, although they may have had a small effect on the growth of given states or localities within the Sunbelt (Vaughan, 1979; Pluta, 1980; Kieschnick, 1981; Harrison and Kanter, 1978; Boren, 1980; and Moriarty _et al._, 1980). The evidence indicates that state and local taxes are a very small percentage of output value and that geographical variation in the amount of taxes paid is a small percentage, less than 5 to 10 percent, of locationally variable costs. Labor costs, access to markets, raw material prices, transportation costs, amenities, and infrastructure all are more important to the firm and vary more between regions, indicating choice of region is more likely to be determined by variation in these costs. Within a state or region, labor, transportation, and raw material costs are more uniform, with the result that state and local variations in taxes may be more significant.

Extensive empirical research supports these conclusions. Surveys of company executives on their reasons for locational decisions indicate tax levels and tax incentives have very little impact on decisions even in the minds of businessmen (Moriarity _et al._, 1980). Econometric studies of economic growth show the correlation between growth rates and various measures of state and local taxes are insignificant, even after controlling for other variables (Carlton, 1979; and Kieschnick, 1981).

2. Other State and Local Incentives

States and localities typically offer two other types of incentives, financing assistance, and labor force training. Many state and local programs, some financed in part with federal money, have been designed to increase the availability or decrease the cost of capital to firms agreeing to locate in the state or locality. Various programs make grants and loans, guarantee commercial loans, and build facilities that are then leased or sold on favorable terms (Moriarty _et al._, 1980, pp. 276-90). Such incentives are available throughout the nation, although certain

Sunbelt states--Alabama, Mississippi, Texas, and Oklahoma--have particularly active programs (Padda, 1981). Several Sunbelt states--Florida, North Carolina, and Kentucky in particular--offer extensive labor force development programs to industry (Clarke and Dodson, 1979; North Carolina, n.d.; Kentucky, n.d.). Both Kentucky and North Carolina offer training programs individualized to the needs of new and existing employers.

The impact of these programs on the location of industry is uncertain and has attracted little research. Such services are useful to firms, but it is unclear whether these programs actually influence locational or expansion decisions or whether they simply provide a valued subsidy to industry without any reciprocal benefits accruing to the public. Financing is generally not a problem for branch plants of established firms because they have access to national capital markets and equity funds. However, small, independent, and high risk firms often do not have access to capital and may benefit from financial incentives. Skills levels have been lower in southern populations so that some form of training has been important to the growth of manufacturing, but many firms are willing to provide training themselves in exchange for a work force with other desirable characteristics.

2.2.8 Summary of Characteristics Affecting Economic Growth

Growth in a regional economy is related to its ability to attract basic industry, or those industries such as manufacturing, agriculture, and mining which serve national markets. From 1920 to 1960, the decline in agricultural employment in the South was so rapid that even a steady rise in manufacturing employment was unable to generate anything but slow population and employment growth. However, since 1960, the decrease in agricultural employment has diminished to the point that a continued steady rise in manufacturing employment has resulted in strong overall economic growth in the South at a time when growth in both manufacturing and total employment has been sluggish in the northern industrial belt.

Considerable controversy exists over the reasons why the South has attracted and continued to attract growth in manufacturing. Among the reasons considered to be most imporant by most analysts are:

- Lower labor costs because of lower wages, a plentiful labor supply, and low levels of union activity;
- Federal spending, especially on retirement benefits, defense salaries, aerospace industries, and infrastructure such as highways;

- The development of a large regional market; and
- The growth of southern cities and the southern manufacturing sector to the point where the available infrastructure and specialized support services, the pool of trained labor, and interindustry linkages attract additional industry.

Of less but still major importance, especially in localized areas, may be the availability of:

- Relatively plentiful, low cost energy supplies;
- Improved transportation;
- Certain raw materials such as agricultural and forest products, petroleum, and minerals; and
- Relatively plentiful water supplies and unpolluted air.

State and local tax rates and tax or other economic incentives are generally thought to be of minor importance to the location of industry in the region, although they do influence the selection of a site within the region. Other state policies contributing to a favorable business climate have not been well studied, with the result that their impact on regional growth rates cannot be evaluated.

Of course, the determinants of industrial location vary by industry and by individual plant within each industry. The previous conclusions about the relative importance of factors of location therefore do not apply equally to all southern industries. For example, energy supplies and prices have been very important in attracting certain primary metals industries to the South, and southern forest resources have been a major cause of the growth in the lumber and wood products and pulp and paper sectors. Thus, even though energy prices and raw materials have been of lesser importance in the overall industrialization of the South, they may be crucial to the growth of certain sectors.

2.3 CHARACTERISTICS ATTRACTING PEOPLE

Considerable evidence suggests the ability of a region to attract industry is not the sole determinant of regional economic and population growth. The ability of a region to attract people, as determined by the amenities and overall quality of life it offers, is also important. This section looks first at the ways the amenities of a region may affect growth and the evidence for the importance of amenities in regional growth in recent years. Then the amenities possessed by the South and their role in southern growth are evaluated.

2.3.1 Effects of Amenities on Growth

The quality of life in a region encourages population and economic growth in three ways--by attracting the retired, by attracting labor force migrants who then create a ready supply of labor that attracts industry, and by directly attracting firms. All three mechanisms generate an economic base, which contributes to the economic and population growth of the region.

A. The Retired

On retiring, people cut some of the ties that have bound them to their region of residence and may decide to move to some other area. Although they are the least mobile of all demographic subpopulations, the retired are in many respects most free to respond to quality of life considerations in their choice of residence. Recent studies have documented the importance of amenities to migration decisions of retirees. For example, one study of retired migrants in the Northcentral Region found that 30 percent cited "environmental" reasons for their choice of destination (Williams and McMillen, 1980). Another national study found that 12 percent of migrating retirees cited climate as a major reason for their move (Plaut, 1981a). The influence of amenity considerations on migration decisions of the retired to the Sunbelt is immediately apparent from the high migration rates of this group to Florida, the mountains of northern New Mexico and northwest Arkansas, and the warm dry regions of southern Texas and New Mexico. The migration of the retired can stimulate the economy of a region. Retirees often bring exogenous sources of income to a region in the form of pensions and savings originating outside of the region and federal transfer payments. All these sources of income can serve as regional economic base. Yet, retirees can also impose burdens on a region in the form of increased demands for publicly provided social and welfare services.

B. Labor Force Migration

Considerable recent evidence suggests that wage earners often enter the labor force in a region for reasons primarily related to amenities rather than economic opportunities, either by actual migration or by searching for employment at a distance. Recent studies indicate that a substantial percentage of households (typically 30 to 75 percent, depending on the subpopulation and geographic area) give primarily consumptive reasons related to housing or the amenities of the location as the reasons for their move rather than productive reasons related to improvement of financial status (Zuiches, 1980; Plaut, 1981a; Williams and McMillen, 1980). Stevens (1980) surveyed recent, nonretired migrants to an amenity-rich and rapidly growing area of southwest Oregon; his results demonstrate that amenities were much more important to the decisions of households to move to this area than were economic considerations. These studies may overemphasize the role of amenities relative to employment factors and may not generalize well to the South, but they do indicate amenities can be very important to the migration of the labor force.

Labor force migration for amenity-related reasons creates in the destination area an available supply of employees often willing to accept wages below those in less desirable areas. Such a labor force may strongly attract certain industrial employers, although disagreement exists on the importance of this mechanism to industrial location, particularly in the South. Much of the disagreement centers around the issue of whether, in general, people follow jobs or jobs follow people. A number of recent econometric studies have investigated the question (Wheaton, 1979b; Muth, 1971; Plaut, 1981b; Steinnes, 1978; Greenwood, 1975; and Olvey, 1972). All concluded that migration and employment growth are interrelated; Muth and Steinnes concluded migration has the best claim to being the first cause, Olvey favored the traditional view that employment growth was primary, and Plaut, Wheaton, and Greenwood refrained from endorsing either position. The overall role of amenities in migration decisions is also controversial. Although the surveys of migrants generally indicate that they believe amenities are very important, econometric studies based on behavior rather than opinion are mixed (Plaut, 1981b; Muth, 1971; Graves, 1976; Cebula and Vedder, 1973). All indicate economic factors--wages, unemployment, and employment growth--are important determinants of migration. Some find that amenity variables such as climate, city size, crime rate, and air pollution influence migration, but others find no such evidence. Wheaton (1979b) presents evidence suggesting that the contradictory results may be because of the existence of two subpopulations of rapidly growing cities--one in which amenities are attracting migrants who then attract industry, and another where traditional determinants of industrial location such as lower wages are attracting industry which then attracts migrants. He finds, however, that with a few exceptions (e.g., Miami, San Antonio, Albuquerque), most rapidly growing Sunbelt cities fall in the category suggesting employment growth rather than amenities is driving expansion.

C. Industrial Location Decisions

Many industries, or functions within industries, are increasingly free of locational constraints, without close ties to either raw material or market sites. Such industries are free to consider the amenities of potential sites and their attractiveness to employees. Such amenities are particularly important to the ability to attract and retain professional and managerial employees. Although evidence about the overall impact of amenities on industrial location decisions is not extensive, there is growing empirical evidence that amenity considerations are important to small entrepreneurs choosing a location for their firm, to facilities with a high proportion of professional and managerial employees, and even to locational decisions for branch plants where cost considerations still predominate (Smith, 1971; Moriarty et al., 1980). In a study of intercity moves of corporate headquarters showing a net movement to the South and the West, Burns and Pang (1977) found such moves were more sensitive to the availability of community amenities than to costs or other business factors.

2.3.2 The Amenities of the South

The South in general, and certain localities in particular, possess a number of amenities identified by migration research as important to the ability of an area to attract people. In addition, income growth, an increase in homogeneity of regional populations, and a growth of the southern metropolitan system have gone far to erase many of the negative features traditionally associated with the South. This section describes southern amenities and discusses recent efforts to describe the overall quality of life in the South.

A. Less Metropolitan Living

Perhaps the most important amenity-related reason given for migration in recent years is a growing preference for a less metropolitan, nonmetropolitan, or even rural environment. The majority of the U.S. population prefers small town living, although the proportion drops dramatically if the small town is far from a metropolitan center or if such a move involves an income cut (Carpenter, 1980; Zuiches and Fuguitt, 1976). Frequently cited contrasts between more metropolitan and less metropolitan areas involve (Stevens, 1980; Williams and McMillen, 1980):

- Desirability as a place to raise children;
- Pace of daily life;
- Safety from crime and violence;
- Crowding and congestion;
- Friendliness of people;
- Environmental pollution;

- Taxes; and

- Cost of living.

The South, with the largest total population of any region, is at present the least metropolitanized of any region in the U.S. (Table 2-10). Only 22 percent of the southern population lives in large metropolitan areas of over 1.5 million population as opposed to 39 to 50 percent of the population in the other regions. In contrast, 36 percent of the South's population lives in nonmetropolitan areas, compared to only 15 percent in the Northeast, 30 percent in the Northcentral Region, and 20 percent in the West. The percentage of the population in each of these categories is not an accurate measure of the availability of less metropolitan areas to the migrant, but it does indicate that the South offers attractive opportunities to the migrant with an antimetropolitan outlook.

Statistics to measure the performance of the South in terms of the attributes associated in the minds of migrants with a less metropolitan environment are often lacking, and it is uncertain to what extent migrants know about or investigate differences in some of these attributes. The South has, however, traditionally had a reputation for a slower, more relaxed pace of life and for the friendliness of its people. As discussed previously, the environmental quality of the South has been favorable. Crime rates were lower in the South in the past, but the most recent data indicate this is no longer true (U.S., Dept. of Commerce, Bur. of Census, 1980, p. 183; 1978 p. 8). Personal taxes and the cost of

TABLE 2-10: REGIONAL POPULATION BY SIZE OF METROPOLITAN AREA, 1977

		Percent of Total Population		
Region	Total Population (1,000)	Large Metropolitan (>1.5 million)	Small Metropolitan (<1.5 million)	Non-metropolitan
Northeast	49,209	57	28	15
North-central	57,941	39	31	30
South	69,849	22	42	36
West	39,262	44	36	20

Source: U.S., Dept. of Commerce, Bur. of Census, 1980, p. 19.

living are still well below national averages, as discussed in a later section.

If the South as a whole, and metropolitan areas in particular, continue to grow rapidly, as they are projected to do, the South will become increasingly metropolitan in character with an increase in metropolitan problems related to congestion, pace of life, crime rate, environmental quality, and so on. Many areas in the South will remain attractive to the migrant with an antimetropolitan bias, but many individual cities and perhaps the region as a whole may lose their distinctiveness in this respect.

B. Climate, Recreational Opportunities, and Landscape

Amenities related to the climate, recreational opportunities, and the landscape increase the attractiveness of an area and have become increasingly important as leisure and incomes increase. Mild winter temperatures--now that air conditioning is widely available to moderate hot, humid summers--have been advanced as a major reason for the recent rapid growth of the southern half of the United States. Even the term "Sunbelt" attests to the widespread perception of the importance of climate. The empirical evidence for the importance of this variable in the migration of the retired is strong; Florida, Texas, and New Mexico, and even the mountains along the top rim of the Sunbelt have received large numbers of migrants from the North attracted to their milder climates. However, the evidence of the importance of climate in the migration of the labor force and industry is mixed. Climate variables are sometimes significant and sometimes insignificant in studies of labor force migration and industrial location after the effect of other variables is accounted for (Wheaton, 1979b; Plaut, 1981b; Graves, 1976; Cebula and Vedder, 1973; Burns and Pang, 1977).

The availability of outdoor recreational opportunities and attractive landscapes--particularly mountains, rivers, lakes, and beaches--appears to contribute significantly to the growth of certain areas of the United States, by attracting both retirees and labor force migrants. The rapid growth of such areas as southwest Oregon, northern California, northern Michigan, and the Rocky Mountain states indicates the influence of these variables (see, e.g., Stevens, 1980). Within the South, the mountains of northwest New Mexico, the Appalachians, the Ozarks, the Florida peninsula, and the many man-made lakes created over the past 50 years present excellent recreation opportunities and attractive landscapes. The rapid growth of many of these areas has been attributed at least in part to these features (Roseman, 1977).

C. Taxes and Cost-of-Living

Regional and metropolitan/nonmetropolitan differences in personal taxes and the cost-of-living exist and can be substantial. Surveys have documented the importance of these variables to many migrants, especially the retired, and employers are finding it increasingly hard to attract high salaried employees to the high income tax states of the North (Weinstein and Firestine, 1978, p. 25; Stevens, 1980; Williams and McMillen, 1980; Marfin, 1981). The South continues to possess definite advantages on both counts. As Table 2-11 indicates, budgets for an intermediate standard of living for a four-person family in metropolitan areas in the South are 1,000 to 3,000 dollars below the U.S. metropolitan average and, in almost all cases, below the U.S. nonmetropolitan average. Although budgets in nonsouthern SMSA's vary, they are rarely as low as budgets in the most expensive southern SMSA and in some cases are up to 6,000 dollars higher. Total state and local taxes per capita, including business taxes but primarily composed of taxes paid by households, ranged in the study area from 553 dollars in Arkansas to 763 dollars in New Mexico in 1978 (U.S., Dept. of Commerce, Bur. of Census, 1980, p. 299). The national average was 888 dollars, with 8 states, including California, Massachusetts, Minnesota, and New York, all above 1,000 dollars.

The South is projected to continue to possess cost-of-living and tax advantages for a number of years. However, these gaps are gradually changing. The cost-of-living is increasing more rapidly in southern cities than in nonsouthern cities (Weinstein, 1981). Taxes have remained low in the South in large part because expenditures on public services have been low. Rapid population growth, requiring new investment in public services, and an influx of migrants used to higher levels of these services may require increases in tax rates.

D. Socioeconomic and Metropolitan Amenities

Prevailing wage levels are generally considered to be a determinant of the attractiveness of a region to migrants, although by no means the only determinant (Richardson, 1978, 1979, pp. 105-13; Muth, 1971; Graves, 1976; Plaut, 1981b). In addition, many people care about the social and economic characteristics of potential neighbors and friends and the ability and willingness of communities to provide high quality public services. The availability of cultural amenities typically associated with metropolitan areas is also important to many migration decisions. High per capita incomes and education levels contribute, but are not necessary, to the provision of many of these amenities. They include the arts, entertainment, professional sports, high quality educational facilities, shopping, and professional services such as medical care. The availability of these amenities has

TABLE 2-11: URBAN INTERMEDIATE BUDGET FOR A FOUR-PERSON FAMILY, 1978

Area	Budget ($)
U.S. Nonmetropolitan	17,016
U.S. Metropolitan	18,982
Southern SMSAs	
Atlanta, Georgia	16,897
Austin, Texas	16,211
Baton Rouge, Louisiana	16,806
Dallas, Texas	16,714
Durham, North Carolina	18,074
Houston, Texas	17,114
Nashville, Tennessee	16,627
Orlando, Florida	16,334
Nonsouthern SMSAs	
Baltimore, Maryland	18,699
Boston, Massachusetts	22,117
Buffalo, New York	19,517
Cleveland, Ohio	18,987
Detroit, Michigan	19,145
Hartford, Connecticut	19,392
Lancaster, Pennsylvania	17,982
Los Angeles-Long Beach, California	17,722
New York, New York	21,587
St. Louis, Missouri	17,897
San Diego, California	17,707
Seattle, Washington	18,671
Washington, D.C.	20,105

Source: U.S., Dept. of Commerce, Bur. of Census, 1979, p. 488.

contributed to the ability of major metropolitan areas to survive in the face of high congestion costs. The importance of access to these amenities is indicated by the fact, cited earlier, that only a small proportion of the population would care to live in a small town if it were far from a metropolitan area. These amenities are especially important to the migration decisions of professional and managerial employees and the location of economic activities relying on such personnel. For example, the amenities most important to the relocation of corporate headquarters include cultural activities, educational opportunities, and entertainment (Burns and Pang, 1977).

In the past, many areas of the South have offered poor wages and have been characterized by high levels of poverty and below-average public services, including education. Because of the lower socioeconomic status of the South and the lack of a well-developed network of metropolitan areas, the South has tended to offer fewer of the cultural amenities associated with the metropolitan areas of the North and the Pacific Coast. The lack of these socioeconomic and metropolitan amenities has acted as a deterrent to the ability of the South to attract migrants, especially professional and managerial migrants.

However, with rising incomes, the growth of cities and metropolitan areas, and the increased cultural homogenization brought about by rapid immigration and media such as television, the South is increasingly able to offer the amenities associated with the richer, more metropolitan areas of the country (see Chapter 3 for a discussion of population and income changes). The image of the South in the minds of potential migrants is changing and is no longer the deterrent to migration that it once was.

E. Overall Quality-of-Life

Recent efforts have tried to combine information on a variety of amenities into indicators that can be used to compare the quality-of-life among cities, states, and regions. During the late 1960's and early 1970's the Midwest Research Institute conducted several quality-of-life assessments. One of their major efforts was intended to produce a picture of conditions in each of the states during the year 1970 (Liu, 1974). The Sunbelt states did not rate highly (see Table 2-12). Some states were consistently rated substandard--for example, Alabama, North Carolina, and South Carolina each received substandard ratings in seven out of the nine indicator areas. At least one-half or more of the 13 states included in the study area were rated substandard in the areas of living conditions, technology, economic status, education, and state and local governments. There were, however, some isolated instances of excellent ratings. New Mexico achieved an excellent rating for technology; Florida's agricultural production was rated excellent based on factors such as capital intensity and the economies of scale used in the state; and Oklahoma was rated excellent both for individual equality and for health and welfare.

Although combining all of these nine indicators to form an overall index for ranking the states may be misleading in some ways, Liu did this in order to compare his study results with other studies. With the exception of Florida, New Mexico, Oklahoma, and Texas, which rated average, all of the states in regions 4 and 6 ranked in the bottom one-fifth of the list. Northern states, on the other hand, tended to be highly rated.

TABLE 2-12: 1970 QUALITY-OF-LIFE RATINGS FOR STATES IN THE STUDY AREA

	States												
	AL	AR	FL	GA	KY	LA	MS	NM	NC	OK	SC	TN	TX
Overall Quality of Life Ranking[a]	50	44	38	41	48	46	49	24	47	33	51	42	37
Individual Status[b]	B	C	B	B	B	C	C	B	B	B	C	B	B
Individual Equality[b]	B	B	C	B	B	C	B	B	C	A	C	B	B
Living Conditions[b]	C	B	B	C	C	C	C	B	C	B	C	B	B
Agriculture[b]	C	B	A	B	C	B	B	B	C	B	B	C	B
Technology[b]	C	C	C	C	C	C	C	A	B	B	C	B	B
Economic Status[b]	C	C	B	C	C	B	C	B	C	B	C	C	B
Education[b]	C	C	B	C	C	C	C	B	C	B	C	C	B
Health and Welfare[b]	C	B	B	B	B	B	B	B	C	A	C	B	B
State and Local Govts.	C	C	B	C	C	B	C	B	C	B	C	C	B

Rating Key: A = excellent, $>(\bar{X} + s)$; B = average, $(\bar{X} \pm s)$;
C = substandard $<(\bar{X} - s)$.

Source: Taken from Liu, 1973; 1974.

[a] Includes 50 states and the District of Columbia.

[b] Based on criteria developed by the Eisenhower Commission on National Goals.

This study has been widely criticized for the way in which the ratings were developed. More than 100 individual variables were used to develop the nine composite measures or indicators described above. A very high proportion of these variables depend heavily on household incomes and on governmental expenditures. Examples are physicians per capita, motor vehicles per capita, number of substandard housing units per capita, and per capita expenditures on education and welfare. The South has never rated highly on such criteria. Variables on which the South could be expected to rate highly, including a nonmetropolitan environment, recreational opportunities, climate, and cost-of-living, were included but did not receive the same emphasis.

Another attempt to measure the desirability of regions to migrants gives a different picture of overall quality-of-life. The study determined whether a nationwide sample of respondents desired to live in some other state than that of current residence (Morgan, 1978). Twenty to 30 percent of the respondents in the Northeast and Northcentral regions desired to move to some other region, but only 14 to 17 percent of those in the South desired to move. If everybody were to move to their state of preference, the South Atlantic Region would increase by 11 percent, the West Southcentral by 1.3 percent, and the East Southcentral would remain constant. The Northeast and Northcentral regions, with the exception of New England, would lose large numbers of people. Thus, according to this measure of regional desirability, which admittedly does not determine which amenities contribute most to a region's desirability, the South ranks considerably above the North but below the West.

2.3.3 Summary of Characteristics Attracting People

The amenities of a region can be important to both the economic and population growth of a region. Amenities can attract the retired whose pensions and savings serve the same function as a basic industry, migrants in the labor force who then form a pool of available labor that attracts industry, and industrial facilities themselves.

The most enduring amenities of the South include the mild winters and the landscapes and recreational opportunities provided by the oceans, beaches, mountains, streams, and the many natural and man-made lakes. Important but less enduring amenities include low personal and property taxes, a lower cost-of-living, and the qualities associated with a less metropolitan way of life such as a more relaxed pace of life, less congestion, and a better place to raise children. All of the above amenities have been shown to be important to many migrants and to the growth of at least certain areas within the South.

At the same time, the South has traditionally offered fewer of the amenities associated with the high income metropolitan areas of the North and the Pacific Coast--high wages, good public services, excellent educational opportunities, and the highest quality of professional services, shopping facilities, and cultural activities. The relative lack of such amenities in the South has hurt its popular image in the past and has been largely responsible for the low ratings often given to the South in overall quality-of-life studies. However, rapidly rising incomes, economic growth, and growing metropolitan populations in the South, as well as the homogenizing effects of television and migration, have narrowed actual and perceived differences between regions in the provision of these amenities.

2.4 SUMMARY

To a considerable extent the recent rapid growth of the South has been determined by the ability of the region to attract people and manufacturing capacity at a time of slow national growth in manufacturing. The relative importance of industrial growth versus population growth as causes in regional growth is highly controversial, as is the relative importance of the differences between the South and other regions in attracting both industry and people to the South. The variables most important to the growth of the overall economic base of the South probably include labor cost and availability, federal spending, energy costs and availability, the growth of the regional market, and the growth of economies related to the size of cities and the concentration of industry within the region. Other factors, such as the availability of raw materials, may be important to individual manufacturing sectors such as pulp and paper and petroleum refining. Of most importance to the ability of the region to attract people are the climate, the recreational opportunities, the availability of less metropolitan settings, the lower cost-of-living and taxes, and the decline in regional disparities in income, education, and availability of metropolitan amenities at a reasonable distance.

Prospects for continued long-term rapid economic and population growth depend on the extent to which regional differences in these variables are likely to persist. The South continues to possess the advantages listed above, and therefore rapid growth is projected to continue for the immediate future. However, changes in any of these variables could slow or reverse the recent growth trends.

Many of the traditional advantages of the South in attracting industry are losing importance and others are gaining importance. Wage levels are converging toward national averages and the pool of surplus agricultural labor has disappeared, although resistance to union activity remains strong in many areas. Federal spending on space and energy is declining, with overall regional disparities in spending disappearing. Energy price and availability disparities may become more important in the near future as the influence of higher energy prices becomes evident, but regional advantages of the South in the cost of certain energy forms are gradually disappearing. As the South grows, high quality air and water resources may become more scarce. Finally, the fact that the industrial innovative capacity of the South lags considerably behind the North and California makes continued industrial expansion less certain if labor and other cost advantages disappear. Thus, the long-term continued growth of the South may depend on the extent to which regional growth has, or can, become self-generating. Continued development of regional markets, continued investment in public and private infrastructure, and the continued existence of economic benefits to further industrial concentration in the region may all become increasingly important determinants of the ability of the South to attract industry. Many experts, but not all, believe that growth in the South has become largely self-generating.

The relative attractiveness of the region to people may also change in the future. The climate, landscapes, and outdoor recreational opportunities of the region are enduring amenities and likely to become more attractive as incomes and leisure opportunities increase. Rising incomes and the growth of southern cities are likely to continue to improve the socioeconomic and metropolitan amenities offered by the South compared to those offered by other regions of the country. At the same time, the growth of the southern economy, population, and cities may reduce the quality of some of the amenities traditionally associated with the South--rural or small town atmosphere, relaxed pace of life, lack of congestion, and a relatively unpolluted environment. The cost of living is rising more rapidly in the South than in other regions, and personal and property taxes may rise in order to expand and upgrade public services and facilities. Thus, many of the differences between regions in socioeconomic characteristics and degree of metropolitanization are likely to gradually disappear, with such natural characteristics as climate, landscape, and recreational opportunities becoming more important in the determination of relative desirability of regions.

In sum, the South is growing rapidly today and is projected to continue to do so for some time. This growth will produce change which can affect those characteristics of the regional system responsible for growth. Both the magnitude of recent and foreseeable economic and population changes, and the probability that rapid growth may continue into the long-term future emphasize the potential for environmental changes in the South. The next two chapters outline current and projected future population, economic, and industrial changes in the South which may affect the southern environment.

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CHAPTER 3

ECONOMIC AND POPULATION CHANGES

HIGHLIGHTS

Status and Trends

1. By 1980, the South had become the most populous region of the United States with a population of just under 64 million. This was 2 million more than the next most populous region, the Northeast. The South continues to be the most rapidly growing region in the nation.

2. Between 1980 and 2010, the South is expected to add about 20 million new residents, an increase of 31 percent. This would represent 42 percent of the total U.S. population increase.

3. The South is experiencing high growth rates in both metropolitan and nonmetropolitan areas. This contrasts with the rest of the country where growth rates in metropolitan areas are well below nonmetropolitan growth rates.

4. Much of this population growth is a result of a turnaround in the direction of migration. Between 1960 and 1970, all but four southern states experienced net outmigration. But between 1970 and 1979, all southern states experienced net inmigration. More than 4 million more people moved to the South than away. This represents half of the total population increase of the South.

5. Manufacturing employment is expected to grow 59 percent in the South from 1978 to 2010. By 2010, the South is expected to have 32 percent of all U.S. manufacturing employment.

6. Because of employment, population, and wage rate changes, per capita incomes in the South are expected to continue to improve. In 1978, the average per capita income in the South was 88 percent of the U.S. average. By 2010, southern per capita income is expected to increase by 122 percent and to reach 95 percent of the U.S. average.

- Geographic Areas

7. Florida and Texas are the most rapidly growing states. Between 1980 and 2010, each is expected to grow by over 40 percent; together they will receive 50 percent of the southern population increase.

8. The growth of manufacturing employment is expected to be rapid in all southern states between 1978 and 2010, but growth rates in Louisiana, New Mexico, Oklahoma, and Texas will be particularly rapid--over 80 percent. Almost one-third of all new southern manufacturing jobs wil be added in Texas.

9. In 1978, per capita incomes approached U.S. averages only in Florida and Texas. Mississippi and Arkansas were falling below 80 percent of the U.S. average. By 2010, Kentucky and Louisiana are expected to also reach at least 97 percent of the U.S. value, and Mississippi and Arkansas are expected to reach 84 percent.

- Key Problems and Issues

10. The projected improvements in per capita incomes provide strong incentives for southern states to continue to encourage economic growth. In addition, population and economic growth will bring other benefits:

    - Decline in the number of dying communities;
    - Decrease in the need for southerners, especially young people, to migrate away from their homes;
    - Improved shopping, professional and other services, and recreational and cultural opportunities as markets for these activities grow; and
    - Increased ability of state and local governments to invest in and improve public services and facilities.

11. However, rapidly expanding populations, particularly urban populations, may bring significant environmental problems:

    - Increased air pollution from an increase in the usage of automobiles and trucks;
    - Need for an increased capacity to supply clean, safe water to households, businesses, and industry;

- Adverse impacts on water quality because of urban runoff and effluent discharge;
- Increased need for sewage treatment facilities;
- Need for solid waste disposal sites;
- Urban sprawl and agricultural and forest land conversion; and
- An increased need for outdoor recreation sites.

CHAPTER 3

ECONOMIC AND POPULATION CHANGES

3.1 INTRODUCTION

The economic and demographic forces discussed in the previous chapter will continue to create substantial changes in the South. The South is projected to add about 20 million people to its population over the next 30 years, representing 42 percent of the total national increase. Migration, particularly from the Northeast and Northcentral regions, is expected to be the source of about a third of this growth.

The growth of employment opportunities in the South is projected to parallel population growth. Manufacturing employment, which is primarily responsible for employment in other sectors, is projected to grow by 60 percent over the next 30 years in the Sunbelt. By 2010, the South will have over 30 percent of all U.S. manufacturing jobs.

The growth of employment opportunities, particularly jobs in higher wage industries, is projected to increase the economic well-being of southerners. Per capita incomes have traditionally lagged behind national averages. However, they are expected to increase about 100 percent by 2010 and reach 95 percent of the U.S. average.

Chapters 3 and 4 describe these changes in further detail. Chapter 3 examines historical and projected changes in population, employment, and income. The substantial benefits of these changes as well as the potential environmental problems created by population growth and urbanization are also discussed. Chapter 4 examines industrial trends in order to identify driving forces which create environmental problems.

3.2 ECONOMIC AND DEMOGRAPHIC PROJECTIONS

The projections of population, employment, and income used in this study are the Regional Economic Projections developed by the Bureau of Economic Analysis (BEA), Regional Economic Division, in the United States Department of Commerce. The BEA data provide (1) historical and projected estimates of population in five age groups by sex, and (2) estimates of employment and earnings in 57 Standard Industrial Code (SIC) groups. The historical series consists of the years 1969, 1973, and 1978; the projected series consists of the years 1985, 1990, 2000, and 2010. Appendix 3A describes the methodology used for these projections. The rest of this section evaluates the usefulness of these projections for the purposes of this study.

The BEA projections are based on several assumptions important to understanding their strengths and weaknesses. First, the projections are based on an extension of past trends, with the historical rate of change in the trend line dampened in the future. This means that the projections assume that factors affecting population and economic relationships in the past will continue to affect them in the future, but that the rate of change decelerates. The danger in such an assumption is that it fails to predict significant changes in trends. For example, the BEA projections made in 1974 failed to predict the acceleration of growth in the early 1970's in several southern states; thus, by the mid-1970's many of the states had already reached their 1980 projection and some had surpassed their 1990 projection.

Secondly, these projections assume that no significant policy changes will occur. Policies do affect population and economic change. For example, certain tax, spending, and labor policies of the federal government, states, and localities have encouraged southern growth, and environmental policies have the potential to affect economic growth. And policies do change, sometimes in response to projections such as these. To the extent that policy changes, growth could be affected in ways not anticipated in these projections. However, one of the chief purposes of the BEA projections is to provide a baseline forecast assuming no policy changes so that the effects of proposed new policies can be estimated.

A third assumption made by the BEA is that resources will be made available for development as needed. If resource constraints appear, the projections will overstate expected growth. As an example of possible problems caused by this assumption, the Sierra Club has voiced the concern that in certain instances the BEA projections have been used to establish a need for water projects when in fact the projected economic and demographic changes are reasonable projections only if the water projects exist (Kunofsky, 1979, p. 5).

Although our analyses are limited by these assumptions, in general these projections are well suited to the purposes of this report. Given the difficulties of any projection methodology, these assumptions are reasonable. They are made with an operational methodology rather than a methodology still in developmental stages. Although they may not predict the future, they describe a future with a high probability. They are consistent, detailed, and widely available. Finally, they are commonly accepted throughout the federal government as a valuable basis for future planning.

3.3 POPULATION

3.3.1 Growth of the South

The population of the South is growing rapidly (Table 3-1). It grew 22 percent from 1970 to 1980, a period over which the nation as a whole grew only 11 percent. The Northeastern and Northcentral regions grew at the even slower rate of about 4 percent each.[1] Only the West grew at a slightly more rapid rate of 23 percent.

This pattern of relative regional growth rates is expected to continue into the future, although annual growth rates are expected to decline slightly. Between 1980 and 2010, the South is expected to grow more rapidly (31 percent) than any region but the West (36 percent). Growth rates in the Northeast and Northcentral regions (7 percent and 15 percent respectively) are projected to be less than half of the rates in the South and West.

In absolute terms, the South is growing more rapidly than any other region. Over the period 1970 to 1980, the South added 11.7 million people--1.4 times more people than the West, 5 times more people than the Northcentral Region and almost 10 times more people than the Northeast. The increase in the South represents 50 percent of total U.S. population growth during this time. From 1980 to 2010, the South is expected to add just over 20 million new residents, 42 percent of the total national increase and 30 percent more than the West, the region projected to have the next largest population increase. Although Region 6 is growing faster than Region 4, the absolute growth in Region 4 is larger because of its larger initial base.

As a result of these trends, the South has moved in rank from the third largest of the four regions in 1960 to the largest region in 1980 (Figure 3-1). Current rankings are expected to continue until the year 2010, with the margin between the South and the next most populous region, the Northeast, increasing. By 2010, 30 percent of the total U.S. population is expected to reside in the South.

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[1] A map showing which states are in each region can be found in Appendix 3A.

TABLE 3-1: REGIONAL DISTRIBUTION OF POPULATION 1960-2000
(in thousands)

Region[a]	1960	1970	1980	1990	2000	2010	Absolute Change	Percent Change	Absolute Change	Percent Change
							1970-1980		1980-2010	
Region 4	27,884	31,856	38,860	42,307	46,636	50,621	7,004	22	11,761	30
Region 6	17,902	20,336	25,043	27,563	30,639	33,288	4,707	23	8,245	33
South	45,786	52,192	63,903	69,870	77,275	83,909	11,711	22	20,006	31
Northeast	54,815	60,660	61,882	63,667	64,929	66,151	1,222	4	4,270	7
North-central	50,306	55,289	57,508	61,047	63,707	65,904	2,219	4	8,396	15
West	28,415	35,071	43,209	48,395	53,935	58,838	8,138	23	15,629	36
Total U.S.	179,323	203,212	226,505	232,979	259,846	274,803	23,293	11	48,298	21

Source: Compiled from U.S., Dept. of Commerce, Bur. of Census. 1980, pp. 10-11; U.S., Dept. of Commerce, Bur. of Census, 1981; and U.S., Dept. of Commerce, BEA, 1980.

[a] The South consists of Federal Regions 4 and 6, the Northeast of Federal Regions 1, 2, and 3, the Northcentral Region of Federal Regions 5 and 7, and the West of Federal Regions 8, 9, 10. See Appendix 3B for included states.

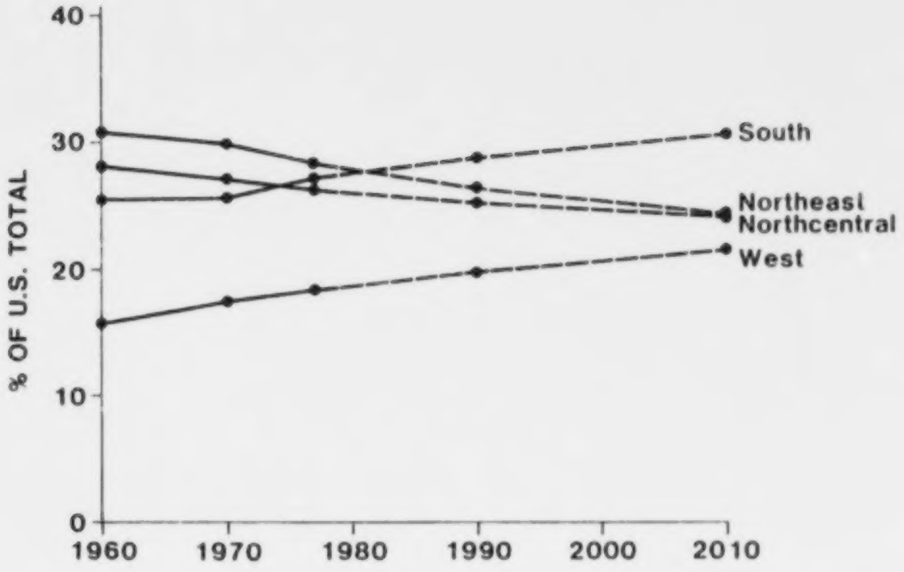


Figure 3-1: Regional Population as a Percentage of the U.S. Total

Source: Table 3-1.

3.3.2 Growth Within The South

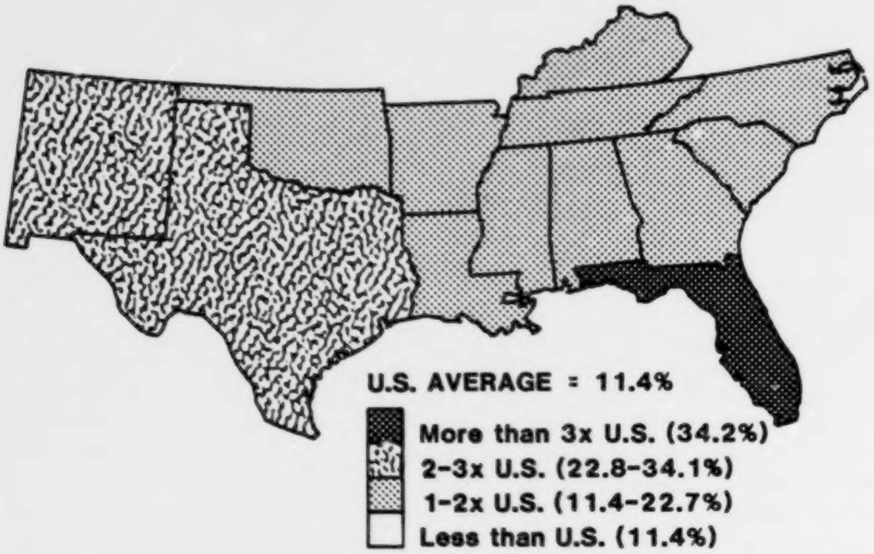
Individual states within the South are growing at widely varying rates, but from 1970 to 1980 all grew more rapidly than the United States average of 11 percent (Table 3-2 and Figure 3-2). Florida was the most rapidly growing state with a growth rate of more than three times the national average, followed by Texas and New Mexico.

In most southern states, growth rates from 1980 to 2010 are projected to continue to be more rapid than the national average but less strongly so than during 1970 to 1980. Florida is projected to drop to between two and three times the national average, and Texas and New Mexico are projected to drop to between one and two times the U.S. average. Only Arkansas and Alabama are projected to grow at rates below the national average.

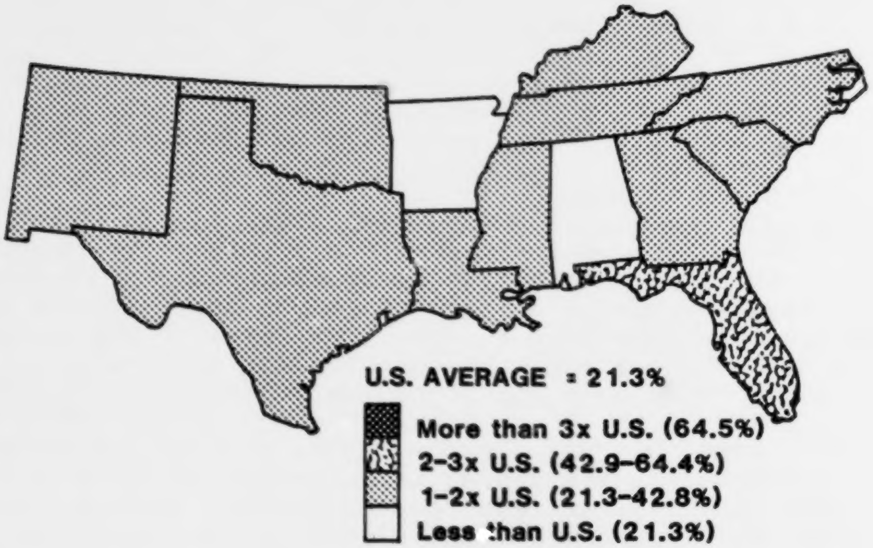
TABLE 3-2: TOTAL POPULATION BY STATE FOR THE SOUTHERN REGION
(thousands)

Region/State	1960	1970	1980	1990	2000	2010	Absolute Change 1970-1980	Percent Change 1970-1980	Absolute Change 1980-2010	Percent Change 1980-2010
Region 4										
Alabama	3,267	3,444	3,890	4,056	4,251	4,483	446	13	593	15
Florida	4,952	6,789	9,740	11,114	12,683	14,142	2,951	44	4,402	45
Georgia	3,943	4,590	5,464	5,715	6,251	6,706	874	19	1,242	23
Kentucky	3,038	3,219	3,661	3,983	4,279	4,548	442	14	887	24
Mississippi	2,178	2,217	2,521	2,709	2,981	3,229	304	14	708	28
North Carolina	4,556	5,082	5,874	6,287	6,871	7,380	792	16	1,506	26
South Carolina	2,383	2,591	3,119	3,344	3,672	4,033	528	20	914	29
Tennessee	3,567	3,924	4,591	5,098	5,648	6,100	667	17	1,509	33
Total	27,885	31,856	38,860	42,307	46,636	50,621	7,004	22	11,761	30
Region 6										
Arkansas	1,786	1,923	2,286	2,361	2,514	2,680	363	19	394	17
Louisiana	3,257	3,641	4,204	4,539	4,901	5,253	563	16	1,049	25
New Mexico	951	1,016	1,300	1,422	1,537	1,627	284	28	327	25
Oklahoma	2,328	2,559	3,025	3,270	3,557	3,810	466	18	785	26
Texas	9,580	11,197	14,228	15,972	18,130	19,915	3,031	27	5,687	40
Total	17,902	20,336	25,043	27,563	30,639	33,288	4,707	23	8,245	33

Source: Compiled from U.S., Dept. of Commerce, Bur. of Census. 1980, pp. 10-11; U.S., Dept. of Commerce, Bur. of Census, 1981; and U.S., Dept. of Commerce, BEA, 1980.



1970-1980



1980-2010

Figure 3-2: Population Growth Rates in the Sunbelt States

Source: Table 3-2.

Over the next 30 years, Florida and Texas, the states with the highest growth rates, are projected to also receive most of the increase in population; Florida is projected to receive 37 percent of the growth in Region 4 and Texas 69 percent of the growth in Region 6. Georgia, North Carolina, Tennessee, and Louisiana are projected to also receive large increments in population. Arkansas and New Mexico are expected to receive the lowest absolute population increases.

3.3.3 Changes in Trends

These population trends represent significant departures from previous patterns of population growth. Most of the South had experienced very slow growth for decades prior to 1970. With only a few exceptions, all southern states except Florida and Texas experienced population growth rates lower than the national average during the three decades 1940-50, 1950-60, and 1960-70. Oklahoma, Arkansas, and Mississippi actually experienced population losses over some decades. However, beginning in the late 1960's population growth rates in the South began to increase dramatically and to surpass national averages. The average annual growth rates for each Sunbelt state for the two decades 1960-1970 and 1970-1980 given in Figure 3-3 attest to the magnitude of the change in growth rates over a short time. All Sunbelt states but Georgia experienced increases in their growth rates at a time when the national growth rate dropped. The growth rate increases for Alabama (0.5 to 1.2 percent), Kentucky (0.6 to 1.2 percent), Mississippi (0.2 to 1.2 percent), South Carolina (0.8 to 1.6 percent) Arkansas (0.8 to 1.7 percent), New Mexico (0.7 to 3.4 percent) and Texas (1.6 to 2.4 percent) are especially striking.

Two mechanisms contribute to regional population growth--net migration and natural increase. Net migration is the difference between the numbers of inmigrants and outmigrants; natural increase is the number of births minus the number of deaths. The major reason for the change in population growth rates is a reversal of migration patterns in the later years of the 1960's. The South was a region of net outmigration for decades prior to 1955. From 1955 to 1970, only significant migration into Florida and Texas resulted in the South being a region of net inmigration (Morrison, 1980, p. 75). The magnitude of the turnaround, again over the space of a few years, is described in Table 3-3. Between 1960 and 1970, all states but Florida, Georgia, Oklahoma, and Texas experienced net outmigration, although excesses of births over deaths prevented any state from actually losing population. From 1970 to 1979, all states experienced net inmigration. In general, inmigration is a more important component in population change in the states of Region 6, with the exception of Louisiana, than it is in Region 4, with the exception of Florida. Inmigration has been predominantly white, but blacks also show a small net movement into the South since 1970 (Berry and

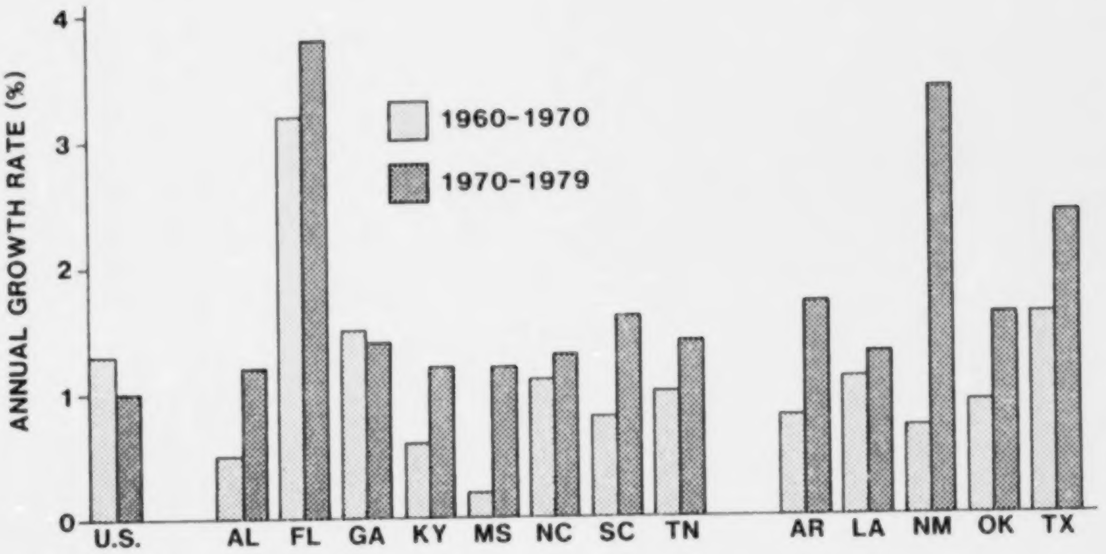


Figure 3-3: Average Annual Population Growth Rate, 1960-1970 and 1970-1980.

Source: U.S., Dept. of Commerce, Bur.of Census, 1980, p. 12.

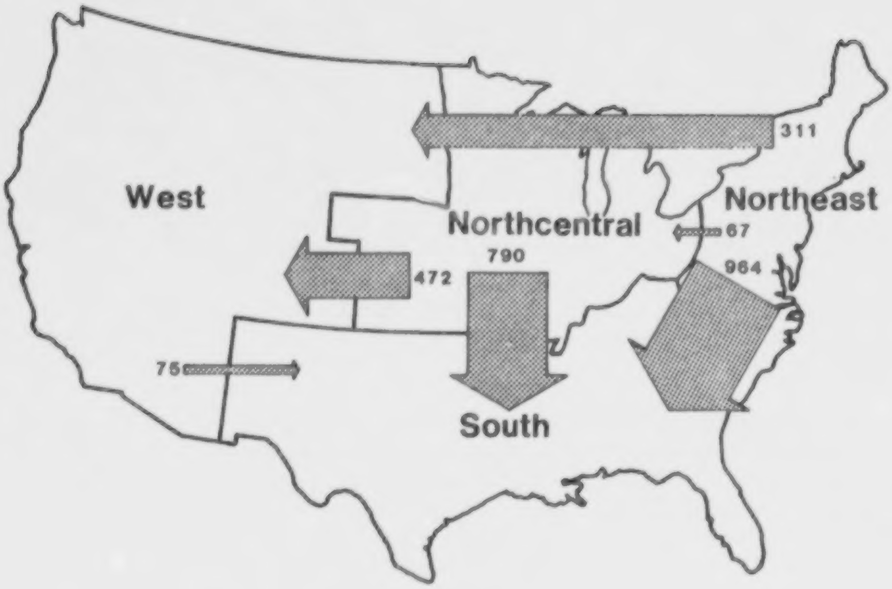
TABLE 3-3: NET MIGRATION FOR THE SOUTHERN REGION (thousands)

Region/State	Net Migration 1960-1970	Net Migration 1970-1979	Net Migration As A % of Total Population Change (1970-1979)
Region 4			
Alabama	-233	75	23
Florida	1,326	1,848	89
Georgia	51	128	24
Kentucky	-153	91	30
Mississippi	-267	7	33
North Carolina	-94	151	29
South Carolina	-149	103	30
Tennessee	-45	202	45
Total	436	2,605	55
Region 6			
Arkansas	-71	136	53
Louisiana	-130	34	9
New Mexico	-130	94	42
Oklahoma	13	177	53
Texas	146	1,045	48
Total	-172	1,486	44

Source: Calculated from U.S., Dept. of Commerce, Bur. of Census, 1980, p. 13.

Dahmann, 1980, p. 35). The massive outflow of southern blacks to northern cities beginning in the 1920's has thus been reversed.

The geographical pattern of migration flows between regions between 1970 and 1975 demonstrates a clear outmigration from the northern region of the country into the South and West (Figure 3-4). The South experienced net migration gains from all other regions of the country in numbers more than double the net gain to the West--the only other region now experiencing a net migration gain. The preponderance of net inmigration to the South came from the Northeast and Northcentral regions; more than 1.5 million more people left these regions for the South than moved in the opposite direction.



Note: Figures accompanying arrows indicate numbers of net interregional migrants (in thousands).

Figure 3-4: Net Interregional Migration, 1970-1975

Source: U.S., Dept. of Commerce, Bur. of Census, 1975.

Inmigration is not the only source of southern population growth, however. The South has traditionally had higher rates of natural increase. In 1975, the South had a higher birth rate and a lower death rate than any other region but the West (U.S., Dept. of Commerce, Bur. of Census, 1977, p. 23). As a result, only in Florida was inmigration responsible for more than half of total population increase (Table 3-3). Although natural increase will continue to be an important component of population change, rates of natural increase are rapidly approaching national averages. Age adjusted fertility and mortality rates are already similar to, or lower than, the U.S. average (Poston and Weller, 1981).

3.3.4 Distribution of Demographic Changes

Descriptions of demographic changes in the entire Southern Region and individual states, as described above, provide a general picture of change in the South. However, they do not provide enough detail on the geographic variation of change to allow a comprehensive assessment of both the benefits and costs of population growth.

Growth has different environmental consequences in metropolitan than in nonmetropolitan areas. Rapid growth in metropolitan areas may exacerbate already existing, and in some cases serious, environmental problems created by large concentrations of people. Rapid growth in nonmetropolitan areas may create new environmental problems in areas where few problems already exist, especially where communities are ill-equipped to cope with an influx of population.

One of the characteristics of the 20th century demographic change prior to 1970 was the dominating pattern of rapid metropolitan and slow or even negative nonmetropolitan growth. This pattern held in all major United States regions from 1960 to 1970, with the pattern being more pronounced in the South and the West (Table 3-4). Since 1970, metropolitan growth rates have decreased and nonmetropolitan growth rates have increased in all regions. However, the reversal occurred to a much greater extent in the Northeastern, Northcentral, and Western regions than in the South. Nonmetropolitan growth rates are now greater in these three regions than metropolitan rates, which have dropped to very low levels. Nonmetropolitan areas are even receiving more people in absolute terms in the Northeast and the Northcentral regions; and metropolitan population in the Northeast actually decreased.

In contrast, the South is experiencing substantial growth in both metropolitan and nonmetropolitan counties, with metropolitan areas having the highest rates and receiving the greatest numbers of new residents. Suburban counties within metropolitan areas are receiv-ing the preponderance of metropolitan growth (Berry and Dahmann, 1980, p. 18). Within the nonmetropolitan class of counties, most growth in absolute terms is occurring around urban centers with populations of 2,500 to 25,000, but rural counties with no urban center of more than 2,500 people are also growing rapidly (Berry and Dahmann, 1980, p. 18). Growth also tends to be localized in nonmetropolitan counties surrounding metropolitan areas.

Not all Sunbelt states follow the pattern typical of the South as a whole, however. Kentucky, on the border of the northern manufacturing belt, follows the metropolitan outmigration and nonmetropolitan inmigration typical of the North (Morrill, 1979). The delta states of Mississippi and Louisiana exhibit the

TABLE 3-4: METROPOLITAN AND NONMETROPOLITAN POPULATION GROWTH (thousands)

	Percent Change				Absolute Change	
	Metropolitan		Nonmetropolitan		Metropolitan	Nonmetropolitan
Region[a]	1960-1970	1970-1978	1960-1970	1970-1978	1970-1978	1970-1978
Region 4	23	15	4	11	2,815	1,496
Region 6	21	17	1	10	2,263	653
South	22	16	3	11	5,087	2,149
Northeast	13	-2	7	10	-811	1,074
North Central	13	2	3	6	749	855
West	28	13	7	20	3,741	1,391
Total U.S.	18	6	4	10	8,757	5,469

Source: Calculated from U.S., Dept. of Commerce, Bur. of Census, 1980, p. 20.

[a] The South consists of Federal Regions 4 and 6; the Northeast of Federal Regions 1, 2, and 3; the Northcentral Region of Federal Regions 5 and 7, and the West of Federal Regions 8, 9, 10. See Appendix 3B for included states.

metropolitan inmigration and nonmetropolitan outmigration typical of the pre-1970 South.

The preceding analysis, based only on the distinction between metropolitan and nonmetropolitan areas, does not indicate the spatial extent of demographic change. Is growth concentrated in a few metropolitan and nonmetroplitan sites with outmigration and population decline still the rule, or is growth widespread throughout the South? The answer, important to understanding both the benefits and costs of growth in the South, is that growth rates do vary, but that the reversal of outmigration to inmigration and the increase in population growth rates which began in the South as a whole around 1970 was widespread throughout the South.

County level data on total population change and net migration for 1960 to 1970 and 1970 to 1976 support this conclusion (Figure 3-5). From 1960 to 1970, more than 70 percent of the counties in all Sunbelt states except Florida, Arkansas, and Oklahoma experienced net outmigration. In spite of high rates of natural increase, this outmigration was severe enough that 40 to 60 percent of the counties in all states except Florida, North Carolina, Tennessee, Arkansas, and Lousiana actually lost population. From 1970 to 1976, the percentages of counties experiencing outmigration and population loss dropped dramatically. Only Louisiana, Mississippi, Alabama, South Carolina, and Texas experienced outmigration in more than 40 percent of their counties. And only in Texas and Louisiana did more than 30 percent of the counties lose population.

Although these data do indicate growth is widespread throughout the South, they also indicate that growth rates do vary, with some areas experiencing outmigration and population loss. Twelve of the Standard Metropolitan Statistical Areas (SMSA's) with populations over 200,000 grew at a rate greater than 20 percent between 1970 and 1977 (see Appendix 3B). Five of these are in Texas and five are in Florida. However, one SMSA with over 200,000 population--Columbus, Georgia--lost population, and twelve experienced net outmigration. An even greater number--particularly older metropolitan areas such as Atlanta and Savannah, Georgia; Huntsville and Birmingham, Alabama; Louisville, Kentucky; Memphis, Tennessee; and New Orleans, Louisiana--experienced population loss in the central county of the SMSA, a pattern long familiar in northern cities (SGPB, 1976, p. 21; and Berry and Dahmann, 1980, p. 18).

Rates vary among nonmetropolitan areas also. Areas receiving rapid inmigration (rate of inmigration exceeding 5 percent of 1970 population) in the 1970's included eastern Oklahoma and northwestern Arkansas, central and eastern Texas, the Tennessee Valley and northeastern Alabama, eastern Kentucky, northern Georgia and western North Carolina, and the Florida Peninsula

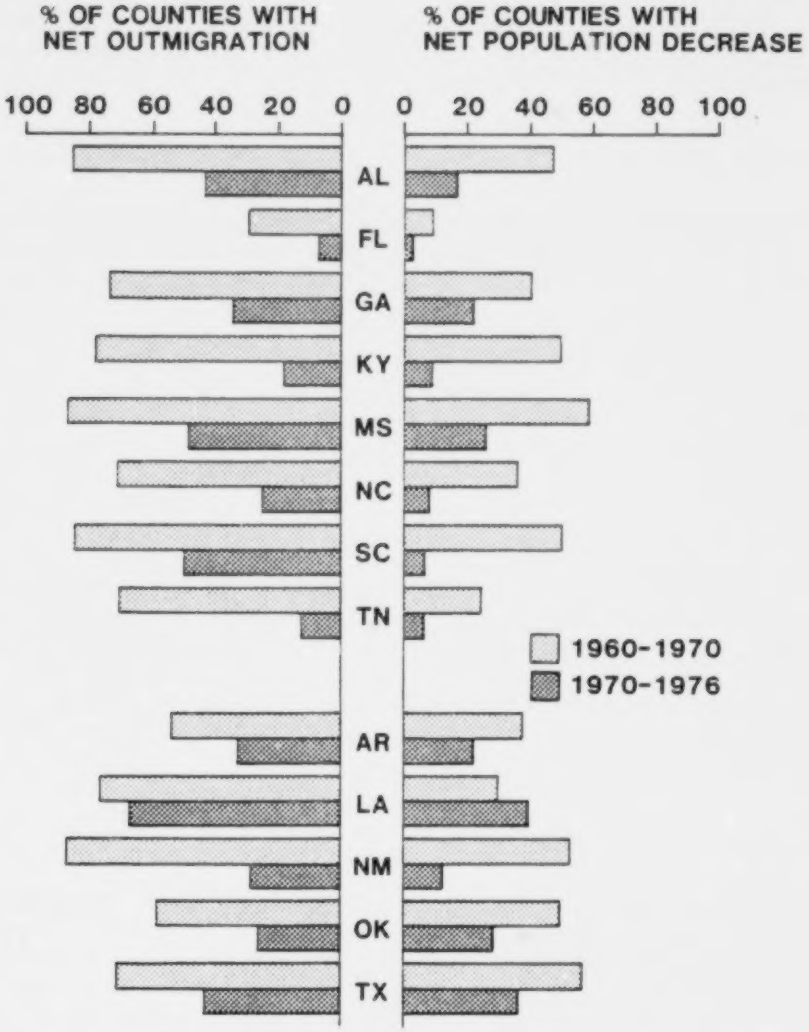


Figure 3-5: Percentage of Counties Experiencing Net Outmigration Loss or Net Population Loss: 1960-1970 and 1970-1976

Source: U.S. Dept. of Commerce Bur. Census, 1977, pp. 29-546.

(Roseman, 1977, p. 20; and Kirschten, 1981). In contrast, certain areas still are experiencing outmigrations. Although outmigration in most of these counties between 1970 and 1975 was considerably diminished over previous decades, it still was severe enough in some cases to produce population loss. Areas continuing to experience population loss included many arid, rural counties of western Texas and Oklahoma; Arkansas, Louisiana, and Mississippi counties along the Mississippi River; and counties in southcentral Alabama (Kirschten, 1981, p. 2020).

3.3.5 Growth of the Population of Older Persons

The demographic patterns of the older age group (over 65 years) are of particular concern because this group is more sensitive to certain environmental health risks such as air pollution. In the South, as in the U.S., the population is getting older as a result of declining birth rates (Table 3-5). The proportion of persons over 65 is projected to rise during the period from 1970 to 2010 from 10 to 13 percent in the U.S., from 10 to 15 percent in Region 4, and from 9 to 12 percent in Region 6. The increase is especially pronounced in Florida where the proportion is expected to reach 24 percent in 2010. These increases are a result of the natural aging of the southern population and of high migration rates of the elderly from the Northeast and the Northcentral regions to the South, especially Florida, Texas, and North Carolina. Although, in general, the over 65 age group is the least mobile of the U.S. population, the migration rate of the elderly to the South Atlantic and East Southcentral regions exceeds the migration rate for other age groups (Plaut, 1981, p. 106). As a result of these trends, regions 4 and 6 are projected to see absolute increases in the over 65 age group of 4.5 million and 2.0 million persons, respectively.

3.3.6 Summary

The South, already the most populous of U.S. regions, is expected to grow by 31 percent over the next 30 years, receiving over 40 percent of the U.S. population increase. Florida and Texas are expected to receive about half of this increase, but all states except Arkansas and Alabama are projected to grow more rapidly than the national average. If future trends resemble the trends of the past few years, growth will be widely distributed throughout the South. Both metropolitan and nonmetropolitan areas are growing rapidly but metropolitan areas are receiving the largest absolute increases. Only a relatively small percentage of metropolitan and nonmetropolitan counties are still experiencing extensive outmigration and population loss. These are concentrated among older metropolitan central cities and the high plains of Texas and Oklahoma, rural areas along the Mississippi River, and the old cotton belt of southern Alabama and Mississippi.

TABLE 3-5: INCREASE IN THE PROPORTION AND NUMBER OF PERSONS OVER 65 IN THE SOUTH
(thousands)

Region/State	Percentage of Total Population 1970	2010	Increase in Number of Persons 1970-2000
Region 4			
Alabama	10	13	249
Florida	15	24	2,337
Georgia	8	12	416
Kentucky	11	12	198
Mississippi	10	13	190
North Carolina	8	14	594
South Carolina	7	11	269
Tennessee	10	13	381
Total	10	15	4,520
Region 6			
Arkansas	12	14	128
Louisiana	8	11	293
New Mexico	7	12	127
Oklahoma	12	13	191
Texas	9	11	1,220
Total	9	12	1,960
U.S.	10	13	14,768

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

These rapid growth rates are a clear break with pre-1970 growth patterns. Before this time, the South had been a region of slow population growth and widespread outmigration. Beginning in the late 1960's, migration into the South accelerated. Between 1970 and 1975 about 1.7 million more persons moved to the South than moved away, with all states and most counties receiving net inmigration.

3.4 EMPLOYMENT

3.4.1 Total Employment

Trends in employment are very similar to those in population (Table 3-6). Growth in employment in the South shows strong

TABLE 3-6: EMPLOYMENT BY REGION AND STATE, 1969-2010
(thousands)

Region/State[a]	1969	1978	1990	2000	2010	Absolute Change 1969-1978	Percent Change 1969-1978	Absolute Change 1978-2010	Percent Change 1978-2010
Region 4									
Alabama	1,304	1,584	1,918	2,073	2,193	280	22	609	38
Florida	2,642	3,808	4,982	5,673	6,207	1,166	44	2,399	63
Georgia	1,984	2,429	2,912	3,171	3,374	445	22	945	39
Kentucky	1,213	1,484	1,916	2,112	2,252	271	22	768	52
Mississippi	812	1,008	1,269	1,445	1,589	196	24	581	58
North Carolina	2,288	2,749	3,312	3,620	3,837	461	20	1,088	40
South Carolina	1,094	1,338	1,694	1,898	2,062	244	22	724	54
Tennessee	1,618	2,029	2,643	2,909	3,121	411	25	1,092	54
Total	12,956	16,467	20,644	22,900	24,634	3,511	27	8,167	50
Region 6									
Arkansas	725	931	1,128	1,237	1,323	206	28	392	42
Louisiana	1,346	1,699	2,176	2,428	2,637	353	26	938	55
New Mexico	370	521	660	730	784	151	41	263	51
Oklahoma	998	1,268	1,574	1,726	1,850	270	27	582	46
Texas	4,620	6,235	8,140	9,252	10,146	1,615	35	3,911	63
Total	8,059	10,654	13,678	15,372	16,740	2,595	32	6,086	57
South	21,105	27,121	34,322	38,272	41,374	6,016	29	14,253	53
Northeast	26,210	27,970	31,644	32,338	32,905	1,760	7	4,935	18
Northcentral	23,424	26,545	31,088	32,505	33,613	3,121	13	7,068	27
West	14,767	19,492	24,932	27,828	30,103	4,725	32	10,611	54
Total U.S.	85,416	101,928	121,986	130,943	137,995	15,712	18	36,867	37

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] The South consists of Federal Regions 4 and 6; the Northeast of Federal Regions 1, 2, and 3; the Northcentral region of Federal Regions 5 and 7, and the West of federal regions 8, 9, 10. See Appendix 3B for included states.

contrasts to the pattern for the Northeast, the Northcentral region, and the nation as a whole. The growth rate of southern employment from 1969 to 1978 was 29 percent as compared to 18 percent for the nation, 13 percent for the Northcentral region, and 7 percent for the Northeast. Only in the West was the growth rate (32 percent) more rapid than in the South. The South increased its total number of jobs by over 6 million, the largest absolute increase of any region.

As a result, the South has moved from third among the four regions in 1969 to second in 1978; it is projected to surpass the Northeast sometime between 1978 and 1985. Employment growth rates in all Sunbelt states were more rapid than the growth rate for total U.S. employment. Employment grew most rapidly in Florida, Texas, and New Mexico; Florida and Texas together received 45 percent of the increase in jobs. Employment grew more slowly in Region 4, with the exception of Florida, than it did in Region 6.

Most of these trends are expected to continue through 2010. The South is projected to continue to have the second highest employment growth rate in the nation and to add the greatest absolute number of jobs (14.3 million). This would represent 39 percent of the increase in U.S. employment. Employment growth in each of the states within the South is projected to continue to occur at a rate greater than that for the U.S. Texas and Florida are projected to grow most rapidly and to add the most jobs. However, the states of Region 4 are not projected to continue to have the lowest growth rates; several of these states--Kentucky, Mississippi, South Carolina, and Tennessee--are projected to experience the more rapid growth typical of the South as a whole.

3.4.2 Manufacturing Employment

The primary impetus for the rapid growth in total employment in the South is manufacturing employment. As a basic industry producing for a national market, manufacturing generates service employment in the other sectors. In the nation, growth of manufacturing employment has been slow, only 2 percent between 1969 and 1978 (U.S., Dept. of Commerce, BEA, 1980). However, the shifts in manufacturing employment among regions have been dramatic. Between 1969 and 1978, manufacturing employment in the Northeast declined by 12 percent, while in the South it increased by 16 percent.

The trends are expected to continue. Over the next 30 years, manufacturing employment in the South is expected to increase by 59 percent compared to a 26 percent increase for the U.S. and a 5 percent decrease for the Northeast (Table 3-7). The South is projected to move from third in manufacturing in 1978 to first in 2010, with 32 percent of all U.S. manufacturing employment.

TABLE 3-7: CHANGE IN MANUFACTURING EMPLOYMENT, 1978-2010
(thousands)

Region/State[a]	Employment 1978	Employment 2010	Absolute Change 1978-2010	Percent Change 1978-2010
Region 4				
Alabama	375	521	146	39
Florida	431	699	268	62
Georgia	523	667	144	28
Kentucky	298	442	144	48
Mississippi	241	428	187	78
North Carolina	814	1,091	277	34
South Carolina	395	588	193	49
Tennessee	532	799	267	50
Total	3,609	5,235	1,626	45
Region 6				
Arkansas	222	312	90	41
Louisiana	213	422	209	98
New Mexico	35	64	29	83
Oklahoma	177	334	157	89
Texas	978	1,932	954	98
Total	1,624	3,065	1,441	89
South	5,233	8,300	3,067	59
Northeast	6,507	5,801	-256	-4
Northcentral	6,582	7,478	896	14
West	3,024	4,701	1,677	56
Total U.S.	20,896	26,280	5,381	26

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] The South consists of Federal Regions 4 and 6; the Northeast of Federal Regions 1, 2, and 3; the Northcentral Region of federal regions 5 and 7, and the west of federal regions 8, 9, 10. See Appendix 3B for included states.

Clearly the traditional stereotypes of industrial Northeast and rural South do not reflect current and future realities.

Within the South, manufacturing employment in 1978 was concentrated in Texas, North Carolina, Tennessee, and Georgia. Louisiana, Oklahoma, and New Mexico had the smallest numbers of manufacturing employees. Manufacturing employment in all states is projected to increase more rapidly than the U.S. average, particularly in Louisiana, New Mexico, Oklahoma, and Texas, with increases of more than 80 percent. The slowest growth rates are projected to be found in the already highly industrialized states of North Carolina and Georgia. Absolute increases will be highest in Texas, North Carolina, and Tennessee--states with large concentrations of manufacturing employment in 1978--plus Florida and Louisiana. These five states are projected to receive over one-third of the total increase in U.S. manufacturing employment with Texas receiving almost 20 percent.

3.4.3 Distribution of Employment Change

As with population change, employment change has not been uniformly distributed. From 1970 to 1977, 81 percent of the increase in southern manufacturing employment occurred in nonmetropolitan areas (Hansen, forthcoming). In contrast, employment in service industries is more likely to occur in metropolitan areas than is manufacturing employment. Growth in both total employment and manufacturing employment is more rapid in certain geographical areas of the South than in other areas (Figure 3-6). Total employment is growing very rapidly along the Gulf and Atlantic coastlines with interior clusters of rapid growth in eastern Tennessee and Kentucky, northern Georgia, northwestern Arkansas and eastern Oklahoma, and the Albuquerque, New Mexico area.

Total employment is growing slowly (less than 15 percent) in only a few scattered areas--southwestern Oklahoma and adjoining counties of Texas and interior areas of Alabama, Georgia, and the Carolinas. Growth in manufacturing employment shows slightly different patterns. The eastern half of the study area no longer contains areas with rapid (greater than 30 percent) growth rates, with the exception of the southern tip of Florida; in fact, many counties across Alabama, Georgia, and the western Carolinas with large existing concentrations of manufacturing experienced relatively slow growth rates in manufacturing employment. However, large areas of New Mexico, Oklahoma and southwestern Texas with low levels of existing manufacturing experienced growth rates in manufacturing employment significantly higher than growth rates in total employment.

3.4.4 Employment to Population Ratio

Change in the employment to population ratio is important to changes in individual economic well-being within a region. The South has been a region of low employment to population ratios. Only the relatively industrialized states of North Carolina, South Carolina, Georgia, and Texas had employment to population ratios in 1978 higher than those for the U.S. (Table 3-8). The ratio, expressed as a percentage of the value for the entire U.S.,

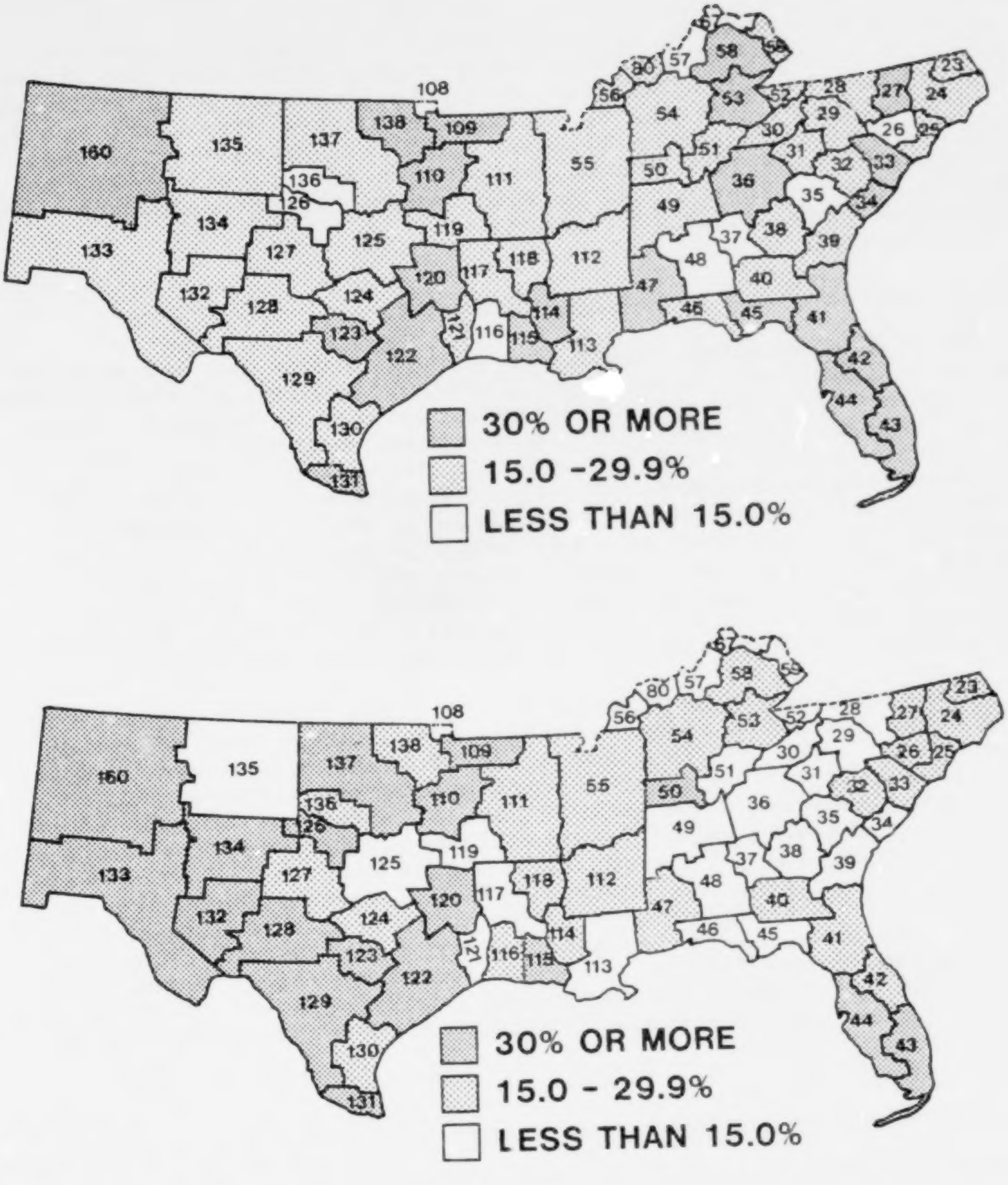


Figure 3-6: Rate of Change in Total Employment (top) and Manufacturing Employment (bottom) by BEA Economic Region, 1969-1978.

Source: U.S. Dept. of Commerce, BEA, 1980.

TABLE 3-8: INDEX OF EMPLOYMENT/POPULATION, 1969-2010

Region/State[a]	Index of Employment/Population[b] 1969	 1978 (U.S. = 100)	 2010
Region 4			
Alabama	91	93	99
Florida	94	96	87
Georgia	102	103	100
Kentucky	92	93	99
Mississippi	87	91	99
North Carolina	107	106	103
South Carolina	102	103	104
Tennessee	96	99	100
Total	96	98	98
Region 6			
Arkansas	90	91	98
Louisiana	88	92	100
New Mexico	86	93	96
Oklahoma	94	96	98
Texas	98	103	101
Total	91	95	98
South	94	97	98
Northeast	103	100	100
Northcentral	101	101	101
West	103	108	102

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] The South consists of Federal Regions 4 and 6; the Northeast of Federal Regions 1, 2, and 3; the Northcentral Region of Federal Regions 5 and 7, and the West of Federal Regions 8, 9, 10. See Appendix 3B for included states.

[b] The employment to population ratio in each state is expressed as a percentage of the ratio for the U.S. as a whole.

has been especially low in the rural delta states of Arkansas (91 percent), Louisiana (92 percent), and Mississippi (91 percent).

Unemployment and labor force participation rate statistics shed some light on these values (Table 3-9). The labor force participation rate is the percentage of the total adult population that is employed plus the percentage that desires and is actively searching for employment. The unemployment rate is the percentage of those in the labor force that do not have jobs; those who want a job but are not actively searching are not included among the unemployed. Unemployment statistics indicate high unemployment is not a major cause of these low employment to population ratios; only Florida, Alabama, Arkansas, and New Mexico had average unemployment rates greater than the national average of 7.0 percent in the late 1970's (Table 3-9). Rather, one of the major explanations is labor force participation rates which are below the U.S. average of 63.7 percent in all states but Georgia (64.2 percent), the Carolinas (66.5 and 63.8 percent), and Texas (65.7 percent). These are the states with high employment to population ratios. Alabama, Florida, Arkansas, and Louisiana had especially low rates, below 60 percent. It is unclear from available data whether these low labor force participation rates are a result of a large number of people who genuinely do not want employment or a large number of discouraged job seekers who have stopped looking for employment. Higher labor force participation rates in the most highly industrialized states do suggest a connection between employment opportunities and probability of participation in the labor force.

With more rapid growth in employment than in population over the next 30 years, employment to population ratios in the South are expected to converge on the U.S. average (Table 3-8). Only Florida and New Mexico are not expected to reach 98 percent of the U.S. average; the continued low index for Florida is a function of that state's high proportion of retirees.

3.4.5 Summary

Employment growth is a major determinant of population growth. Patterns of employment growth presented in this section are similar to those presented in the previous section on population growth. Employment in the South is growing more rapidly in absolute terms than any other region and at a rate second only to that for the West. Employment growth is projected to continue to be concentrated in Florida and Texas, although employment growth rates in all Sunbelt states are projected to be more rapid than for the U.S. Because employment is projected to increase slightly more rapidly than population, employment to population ratios are projected to draw near to U.S. averages throughout most of the South.

TABLE 3-9: UNEMPLOYMENT AND LABOR FORCE PARTICIPATION RATES

Region/State	Average[a] Unemployment Rate 1975-1979	Labor Force Participation Rate 1979
Region 4		
Alabama	7.1	59.6
Florida	8.1	56.8
Georgia	6.9	64.2
Kentucky	5.7	61.3
Mississippi	7.0	58.6
North Carolina	6.0	66.5
South Carolina	6.7	63.8
Tennessee	6.4	61.2
Region 6		
Arkansas	7.1	59.9
Louisiana	7.0	59.6
New Mexico	7.9	62.2
Oklahoma	5.0	60.6
Texas	5.1	65.7
Total U.S.	7.0	63.7

Source: Calculated from U.S., Dept. of Commerce, Bur. of Census, 1980.

[a] Calculated by averaging the annual unemployment rates for each of the five years.

Growth in manufacturing employment provides the major thrust for overall employment growth in the South. At a time when manufacturing employment is growing slowly in the U.S. and even declining in the Northeast, manufacturing employment is projected to grow by 59 percent in the South between 1978 and 2010. This growth represents three out of every five new U.S. manufacturing jobs. Absolute increases in both total employment and manufacturing employment will be largest in Florida, Georgia, North Carolina, Tennessee, and Texas--states with the largest existing shares of both total and manufacturing employment. Only Florida and Texas of the above five states are projected to have high growth rates in both total employment and manufacturing employment. In addition, Mississippi, Louisiana, New Mexico, and

Oklahoma are projected to experience especially rapid growth rates of manufacturing employment.

3.5 INCOME

3.5.1 Per Capita Income

For decades, the South has been a relatively impoverished region. Although southerners have participated in national increases in real per capita income, per capita incomes in the South are significantly below the U.S. average (Table 3-10). In 1978, the average per capita income for the South was 88 percent of the U.S. average. Among individual states, only Florida and Texas were near the U.S. average, and Mississippi and Arkansas, fell below 80 percent of the U.S. average. Even when per capita income figures are adjusted for well-known cost of living differentials, the South still lags (Jusenius and Ledebur, 1977, pp. 140-41). These income differentials have provided strong incentives for southern communities and states to encourage economic growth.

Improvements in per capita income in all states within the South are expected to continue. Per capita income in noninflated 1972 dollars in the South is expected to increase from 4,630 dollars in 1978 to 10,494 dollars in 2010, an increase in purchasing power of over 100 percent. Relative to projected increases in the U.S. as a whole, this increase is not so impressive. Per capita income in the South as a whole is projected to increase from 88 to 95 percent of the U.S. average. Florida, Kentucky, Louisiana, and Texas are the only states projected to be within three percentage points of the U.S. average. Many states are projected to lag; per capita incomes in Mississippi, South Carolina, and Arkansas are expected to still be below 90 percent of the U.S. average.

3.5.2 Wage Rates

Per capita income increases are produced by the combination of increases in the employment to population ratio, discussed under employment, and increases in wage rates. The South has had the lowest wage rates in the country as well as low employment to population ratios; earnings per employee,[1] a measure of wage rates, were only 90 percent of the U.S. average in 1969 (Table 3-11). Only Kentucky, Louisiana, New Mexico, and Texas had ratios above 90 percent of the U.S. average. Ratios in North Carolina, South Carolina, and Arkansas were 85 percent or less of the U.S. figures.

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[1] The measure is calculated by dividing total labor and proprietors income by total employment.

TABLE 3-10: PER CAPITA INCOME
(thousands)

Region/State[a]	Per Capita Income (1972 dollars)			Percent of U.S. Per Capita Income		
	1969	1978	2010	1969	1978	2010
Region 4						
Alabama	3,046	4,217	10,204	73	81	93
Florida	3,883	5,052	10,856	94	97	98
Georgia	3,499	4,519	10,203	84	86	93
Kentucky	3,240	4,403	10,741	78	84	97
Mississippi	2,630	3,721	9,287	63	71	84
North Carolina	3,383	4,426	10,108	82	85	92
South Carolina	3,105	4,195	9,817	75	80	89
Tennessee	3,250	4,374	9,924	78	84	90
Total	3,367	4,489	10,322	81	86	94
Region 6						
Arkansas	2,903	4,081	9,481	70	78	86
Louisiana	3,208	4,492	10,700	77	86	97
New Mexico	3,187	4,399	10,028	77	84	91
Oklahoma	3,470	4,751	10,445	84	91	95
Texas	3,700	5,164	11,065	89	99	100
Total	3,503	4,848	10,754	84	93	97
South	3,419	4,630	10,494	82	88	95
Northeast	4,526	5,389	11,169	109	103	101
Northcentral	4,267	5,376	11,334	103	103	103
West	4,424	5,681	11,332	106	109	103
Total U.S.	4,154	5,233	11,037	100	100	100

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] The South consists of Federal Regions 4 and 6; the Northeast of Federal Regions 1, 2, and 3; the Northcentral Region of Federal Regions 5 and 7, and the West of Federal Regions 8, 9, 10. See Appendix 3B for included states.

TABLE 3-11: EARNINGS PER EMPLOYEE
(thousands)

Region/State[a]	Earnings per Employee (1972 dollars)			Percent of U.S. (average)		
	1969	1978	2010	1969	1978	2010
Region 4						
Alabama	6,671	7,772	16,224	84	89	95
Florida	7,361	7,660	15,161	93	88	94
Georgia	6,728	7,675	15,678	85	88	92
Kentucky	6,525	7,939	16,881	82	91	99
Mississippi	5,979	6,879	14,459	75	79	84
North Carolina	6,290	7,342	15,210	79	85	89
South Carolina	6,197	6,998	14,570	78	81	85
Tennessee	6,620	7,557	15,299	83	87	89
Total	6,647	7,484	15,416	84	86	90
Region 6						
Arkansas	6,166	7,399	14,550	78	85	85
Louisiana	6,671	8,250	17,407	84	95	102
New Mexico	6,511	8,184	15,613	82	94	91
Oklahoma	6,858	7,688	15,703	86	89	92
Texas	7,215	8,485	17,135	91	98	100
Total	6,952	8,243	16,740	87	95	98
South	6,764	7,781	15,950	85	90	93
Northeast	8,353	8,928	17,775	105	103	104
North central	8,268	9,082	17,800	104	105	104
West	8,452	9,051	17,271	106	104	101
Total U.S.	7,954	8,687	17,119	100	100	100

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] The South consists of Federal Regions 4 and 6; the Northeast of Federal Regions 1, 2, and 3; the Northcentral Region of Federal Regions 5 and 7, and the West of Federal Regions 8, 9, 10. See Appendix 3B for included states.

One of the reasons for these low values is the fact that the South has had a disproportionate share of employment in the low wage lumber, furniture, textile, apparel, and leather goods industries (U.S., Dept. of Commerce, Bur. of Census, 1980, pp. 413-15). The relatively low per capita incomes in the Carolinas despite high employment to population ratios can be explained by the concentrations in these states of these low wage industries.

The projections indicate wages will increase substantially. Earnings per employee in the South are expected to rise from 7,781 dollars in 1978 to 15,950 dollars in 2010 in real 1972 dollars, an increase of over 100 percent. Again, although the absolute increase is large, it represents an increase from 90 to only 93 percent of the U.S. average; the South is projected to continue to lag behind other regions. Although all southern states are projected to see great improvements in absolute earnings per employee, only Kentucky, Louisiana, and Texas are expected to reach or come close to the U.S. average. Mississippi, the Carolinas, Tennessee, and Arkansas are projected to continue to fall below 90 percent of the U.S. value.

These changes in earnings per employee are a function of both improvements in productivity and the high rate of growth in the South of the relatively high wage mining, primary metal, transportation equipment, nonelectrical machinery, paper, chemicals, and petroleum refining industries. Between 1970 and 1976, 42 percent of new manufacturing jobs were in these high wage industries where as only 25 percent were in the low wage sectors mentioned previously (Hansen, forthcoming). The variations between individual southern states in the earnings per employee ratio are largely a function of employment patterns in high and low wage industries.

3.5.3 Geographical Distribution of Per Capita Income Change

The geographical distribution of gains in per capita income is an important element in the evaluation of the benefits of economic growth in the South. Per capita income traditionally has been significantly higher in metropolitan areas than in nonmetropolitan areas. This trend continues. However, significant gains in per capita income have been extremely widespread, indicating the benefits of growth are reaching most areas within the Sunbelt (Table 3-12). Most counties receiving the highest percentage gains are often nonmetropolitan counties, although metropolitan areas tend to receive larger absolute gains, counties within each of the states have experienced growth rates in per capita income from 1969 to 1974 greater than the national average of 7.6 percent. Gains are particularly widespread in Region 4. More than 86 percent of the counties in all Region 4 states experienced per capita income growth rates of more than 8 percent. More than 20 percent of the counties in Mississippi, North Carolina, and South Carolina experienced growth rates greater than 10 percent.

TABLE 3-12: GEOGRAPHIC DISTRIBUTION OF CHANGE IN PER CAPITA INCOME, 1969-1974

Region/State	Annual Average Percent Change In Per Capita Income 1969-1974			
	<7	7-8	8-10	>10
		(U.S. =	7.6)	
	(Percentage of counties)			
Region 4				
Alabama	0	6	82	12
Florida	1	1	81	17
Georgia	1	11	73	15
Kentucky	0	14	68	18
Mississippi	0	0	68	32
North Carolina	0	6	64	30
South Carolina	0	2	76	22
Tennessee	0	5	85	9
Region 6				
Arkansas	1	9	68	22
Louisiana	0	17	73	9
New Mexico	28	31	38	3
Oklahoma	5	34	58	3
Texas	11	21	58	10

Source: Calculated from U.S., Dept. of Commerce, Bur. of Census, 1977.

Within Region 6, Arkansas and Louisiana show patterns similar to the states of Region 4. However, New Mexico, Oklahoma, and Texas show a higher percentage of counties with lower growth rates; approximately 20 percent or more of the counties in these three states experienced per capita income growth rates below the national average of 7.6 percent.

3.5.4 Income Distribution

Income distribution, as well as average per capita income, is an important determinant of economic well being. The South has traditionally had the highest proportion of poor people of any region (Table 3-13). In 1969, over 20 percent of individuals in the South were below the poverty level; this percentage did not exceed 12 in any other region. In 1975 the South continued to have a higher percentage of its population below the poverty level. However, this percentage had decreased significantly more

TABLE 3-13: PERCENTAGE OF POPULATION BELOW POVERTY LEVEL

Region[a]	Percentage of Population Below Poverty Level[b] 1969	1975
Region 4	22	17
Region 6	21	17
South	21	17
Northeast	11	9
North Central	11	9
West	12	10
Total U.S.	14	11

Source: Calculated from U.S., Dept. of Commerce Bur. of Census, 1980, p. 467.

[a] The South consists of federal regions 4 and 6; the Northeast of federal regions 1, 2, and 3; the Northcentral Region of federal regions 5 and 7, and the West of federal regions 8, 9, 10. See Appendix 3B for included states.

[b] Adjusted for inflation.

in the South than in any other region, from 21 to 17 percent in the South as opposed to 14 to 11 percent in the entire U.S. These decreases in the percentage of poor people are not just a result of a large inmigration of the nonpoor. All states except Georgia, Florida, and New Mexico showed significant decreases in the absolute numbers of poor people as well as decreases in the proportion of poor in the population (U.S., Dept. of Commerce, Bur. of Census, 1980, p. 467). Fifty percent of the national decrease of 3.1 million in the number of individuals below the poverty level occurred in the South. This indicates that although poverty is still widespread in the South, economic gains in the region as a whole are reaching some of the poor.

3.5.5 Summary

Increases in the employment to population ratio and in wage rates over the next 30 years are projected to continue to increase the economic well being in the South, a region with a long history of below average incomes. Employment to population ratios are projected to rise to near the national average throughout most of the South. Wage ratios are projected to double in constant dollars and rise from 90 to 93 percent of the U.S. average. As a result, per capita incomes are projected to more than double and to rise to 95 percent of the U.S. average. The South as a whole and certain states in particular are projected to continue to lag behind U.S. averages, but the absolute and relative gains are projected to be significant. Although the South continues to have the highest proportion of poor people of any region, income gains are reaching the poor; the number of poor people is declining more rapidly in the South than in any other region.

These income increases are expected to be widely distributed throughout the South. Per capita incomes in all Sunbelt states and in most of the counties within each of the states are growing more rapidly than the U.S. average. Although metropolitan areas have the highest incomes at present, incomes in many nonmetropolitan areas are growing as fast as or faster than in metropolitan areas.

3.6 BENEFITS OF GROWTH

The demographic and economic changes described in previous sections are expected to continue to bring significant benefits to the Sunbelt. Population and income gains are not concentrated in a few locations, but extend to both metropolitan and nonmetropolitan areas throughout the South.

In the past, the South, particularly the nonmetropolitan South, has been a region of low per capita incomes and high poverty. Limited job opportunities have made it necessary for many to migrate to find jobs, particularly young adults. These conditions are changing rapidly. Job opportunities and incomes are increasing more rapidly than the national average, and poverty is decreasing. Change is, if anything, more rapid in nonmetropolitan than in metropolitan areas. The increase in individual economic well-being and the decrease in the need to migrate away from homes in nonmetropolitan areas and the South in general are highly valued benefits to many southerners.

Large areas of the South, and again nonmetropolitan areas in particular, have experienced significant outmigration and population loss. This has led in many areas of the South to a landscape of dying towns, deteriorating business districts and public facilities, and fiscal stringency for many local governments.

These trends have been widely reversed with significant benefits for many localities. Many once-declining towns and cities are growing; perceptions of a positive future without the need for migration are becoming generalized in these localities. An expanding market encourages investment in business and cultural facilities and services. Such investment brings an expanded range, wider variety, and often higher quality of shopping, professional and other services, and recreational and cultural opportunities.

The South traditionally has also had lower quality public services and facilities. In the past, measures of per capita spending on public services generally have shown southern cities to be well below the national average (Liu, 1974). Although some of the regional differences are attributable to other variables such as differences in cultural perspectives towards public functions and responsibilities, some differences are clearly attributable to the fiscal health of localities (Lupsha and Siembieda, 1977). Although providing public facilities and services for an expanding population is expensive, higher household incomes and an expanding tax base in many southern communities may permit improvements in public services and facilities, if desired.

Improved community fiscal well-being and improved public services and facilities can also improve environmental quality. The paving of streets and roads reduces airborne particulates and sedimentation of streams. Improved sewage and wastewater collection and treatment improves water quality. Land use planning and the public acquisition of land or development rights for parks, open spaces, or natural areas can reduce land use conflicts.

3.7 ENVIRONMENTAL PROBLEMS CREATED BY POPULATION GROWTH

Economic and population growth brings substantial benefits, but it also may bring environmental problems, both because it increases the potential output of wastes and because it increases the number of people affected by those wastes. This section describes potential environmental problems created by population growth and general urbanization in the Sunbelt. Volume II describes potential environmental problems associated with the growth of individual industries rather than population itself, and Volume III discusses environmental problems in more detail.

Environmental problems created by population growth will not be uniformly distributed, because growth is not evenly distributed and the capacity of the environment to absorb growth varies. Further, the existence of potential problems does not imply the need to restrict growth. Some problems can be successfully solved and other problems may be an acceptable price to pay for the benefits of growth.

3.7.1 Vehicular Air Emissions

As the population increases in an area, the number of automobiles and trucks and the number of vehicle miles travelled also increase. This is particularly true in southern cities where most growth has occurred in the sprawled manner characteristic of the 20th century and where mass transportation is not common.

Such growth creates the potential for continued air quality problems in many southern communities, many of which already are experiencing air quality problems (see Chapter 11 on Air Quality for extended discussion). In 1977, automobiles and trucks contributed 6 percent of the airborne particulates, 75 percent of the carbon monoxide, 34 percent of the hydrocarbons, and 30 percent of the nitrogen oxides emitted by all sources in the U.S. (U.S., NCAQ, 1981, p. 192). Such emissions are an important factor in the air quality of many southern counties, of which 50 percent experienced violations of national carbon monoxide standards and 76 percent experienced violations of photochemical oxidant standards in 1978 (U.S., CEQ, 1980). Emissions per vehicle mile have decreased since governmental regulation of emissions began in 1968; if statutory requirements in the 1977 Clean Air Act Amendments are met, hydrocarbon, carbon monoxide, and nitrogen oxide emissions per vehicle mile will continue to decrease to less than 50 percent of current levels by 1990 (U.S., NCAQ, 1981, p. 198).

However, the rapid growth of many Sunbelt communities will more than offset these projected emissions declines. Further, there is some question whether these standards will be met for new cars, and in-use automobiles have consistently shown emissions levels greater than standards, particularly for hydrocarbons and carbon monoxide (U.S., NCAQ, 1981, p. 199). As a result, emission of air pollutants by motor vehicles will remain a problem for many Sunbelt counties for the foreseeable future.

3.7.2 Water Quantity and Quality Problems

Larger urban populations will require expanded capacity to withdraw and/or treat water to supply households, businesses, and industry with clean, safe water. A typical U.S. family of four uses about 350 gallons of water a day for inhouse and yard uses (U.S. Water Resources Council, 1978, pt. 3, p. 20). At this rate, even small population increments can create a need for expanded water supply capacity. Increase in the need for municipal water withdrawals at the same time that industry is increasing its withdrawals may result in localized or generalized water shortages in some areas of the Sunbelt.

At least two-thirds of the water used by a typical family leaves the house in the form of sewage. As a result, increased population either increases sewage outfalls into water bodies or increases the need for sewage treatment capacity. Increased urban area also increases urban runoff, which releases more suspended and dissolved substances into water than all natural watersheds (U.S., CEQ, 1979, p. xix). Population growth, therefore, has the potential to contribute to significant water quality conflicts that may limit human use and enjoyment of water resources and may disturb wildlife habitat or fragile, water-based ecosystems such as coastal wetlands (see chapters 12 and 13 for further discussion of water quantity and quality problems).

3.7.3 Land-Use Conflicts

An expanding population, particularly an expanding urban population, frequently generates land-use conflicts. These include conflicts over the conversion of land from rural to urban uses, over recreational land, and over the uses of environmentally sensitive or aesthetically desirable areas. Land-use conflicts often become the focus of local concern over environmental issues because localities frequently have the power to regulate land use but not other driving forces responsible for environmental change. Land-use issues are discussed at greater length in Chapter 12.

A. Rural/Urban Land Conversion

Over 13 million acres of land in the Sunbelt, or a little less than 2 percent of the total land area, were converted from rural to urban or water uses between 1967 and 1977 (USDA and CEQ, 1981). Where conversion occurs on valuable agricultural or forest land, it irreversibly reduces the agricultural land base and potential U.S. agricultural and forest productivity in the face of mounting U.S. and world demands for food, feed, and fiber. Almost 75 percent of the 13 million acres converted in the Sunbelt was potential cropland and at least 30 percent was prime cropland.

Another set of environmental concerns related to land conversion is the way in which land is converted to urban uses. Urban residents in many sections of the country are increasingly concerned about the quality of urban environments created by the conversion process (Reilly, 1973). They are concerned about the loss of open space, urban sprawl and suburban monotony, traffic congestion, and the cost of public services, among other issues.

B. Recreational Lands

A large percentage of the population takes part in outdoor recreation activities, including picnicking, swimming, boating, hiking, riding, camping, fishing, and other water sports. In the South, the most favored activities are fishing and waterskiing

(Knudson, 1980, p. 47). Growing population will increase the need for developed and undeveloped recreational sites at the same time that population pressures on the land base are greatest. The problem is most serious for the very rapidly growing activities of remote wilderness hiking, riding, and camping that require relatively pristine sites with low densities of use per acre.

C. Environmentally Sensitive and Aesthetically Desirable Areas

Environmentally sensitive and aesthetically desirable lands--including open space, natural areas, flood plains, wetlands, and barrier islands--continue to be subject to intense pressures for development throughout the Sunbelt. Yet these lands provide valuable services, one tract often serving several different functions. They serve to separate and identify communities and to create pleasing community landscapes. They provide recreational lands and wildlife habitat. Wetlands, in particular, have a biological productivity far out of proportion to their land area and are vital to numerous economically and recreationally important animal species. Floodplains, wetlands, and barrier islands serve to protect other land areas from environmental hazards such as floods, storms and hurricanes, and coastal erosion. Wetlands can assimilate and treat wastes, up to a point, with little decline in water quality. Finally, these lands help to maintain ecological diversity and stability. As these benefits of preservation have become more widely understood and appreciated, conflicts over the development of such lands have become more intense.

3.7.4 Solid Waste Disposal

The municipal solid waste disposal problem is becoming increasingly important and is closely related to population growth. Waste per capita is high and growing larger. Average municipal waste per capita was about 1,400 pounds per year in 1978 (U.S., CEQ, 1979, p. xiii) and increased by 38 percent between 1970 and 1980 (Melosi, 1981, p. 9). Disposing of this quantity of waste both safely and inexpensively is a serious problem for many cities, expecially large ones.

Simple landfilling is unsightly and odoriferous, encourages vermin, and allows noxious and toxic wastes to leach into surface and ground waters. The sanitary landfill, which became the predominant disposal method after World War II, reduces these problems by alternating compacted layers of wastes with layers of dirt, but problems still exist. Sanitary fills have not eliminated environmental problems. They often contaminate ground water and sometimes produce fumes and gases if not properly monitored. Unless they are vented, methane can migrate and cause fires and explosions. Further, as late as the mid-1970's, 94 percent of 17,000 land disposal sites surveyed did not meet the minimum requirements for a sanitary landfill (Melosi, 1981). By the 1970's, doubt began to emerge that the sanitary landfill represented a long-term solution. In addition to environmental problems, a major concern was the problem of finding suitable sites. As nearby sites reached capacity, cities had to seek suitable sites at considerable distances from collection centers, greatly increasing transportation costs.

Incineration was a major means of disposal in the early part of the century, but increased concern over the relationship between air pollution and incineration lead to its decline. Incineration produces nitrogen oxides, sulfur oxides, and heavy metals. In addition, incinerators often required costly separation of waste compounds, especially as the variety of materials in municipal waste increased, to avoid safety problems and to prevent damage to incinerators. The technology exists today to reduce these problems, at a cost, so that incineration of waste may increase in the future.

Although ocean dumping of municipal waste has diminished in recent years, it has not disappeared. Where it still exists, it can create serious coastal pollution problems and damage the marine environment. An area of several square miles where New York dumped sewage sludge between 1959 and 1968 has been described by critics as "a dead sea of muck and black goo" (Melosi, 1981).

3.8 SUMMARY

The Sunbelt is changing rapidly; trends which emerged in the 1970's were often clear breaks with the past. A region of longtime slow growth, the South is growing today at a more rapid rate than any other region but the West. Because of its relatively large population base, the projected 1978 to 2010 increase in population is larger than any other region, 20 million people or 40 percent of the total U.S. increase. By 1980 the South was the most populous region in the U.S. The Sunbelt's growth is largely a result of rapid growth in employment, fueled by rapid increases in manufacturing employment, which generates employment in other sectors. By 2010, the South is projected to have more manufacturing jobs than any other region. As a result of expanding job opportunities, southerners that once had to leave the region to find jobs are remaining and northerners are increasingly migrating to the South. The South is now, and will continue to be, a region of net inmigration.

The growth of employment, particularly in traditionally high wage industries, is resulting in significant gains in per capita incomes. The South has been an area of low incomes even after adjustment for cost-of-living differentials. However, per capita incomes in the South are growing at rates more rapid than the national average. Thus, all southern states are projected to draw closer, with some states reaching the national per capita income average over the next 30 years.

These changes are widespread throughout the South. Metropolitan areas are still growing most rapidly in terms of both rates and absolute numbers, but nonmetropolitan and even rural areas throughout most of the South are making significant gains in population, employment, and incomes. The decrease in the number of nonmetropolitan counties experiencing population loss and outmigration between 1965 and 1975 is striking in almost all southern states.

Such rapid growth will bring substantial benefits to many southerners and many southern communities. It will also bring increased potential for environmental problems. Increased population may increase vehicular air pollution, require expanded water supply, increase the need for sewage, wastewater, and urban runoff control and treatment, increase rural to urban land conversion, and other land-use conflicts, and increase the problems of municipal solid waste disposal.

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APPENDIX 3A

Bureau of Economic Analysis Projection Methodology[1]

The historical population data used by BEA are those of the Bureau of the Census; the historical data on employment, earnings,[2] personal income, and wages by industrial origin are derived primarily from Bureau of Labor Statistics records developed with the aid of state unemployment insurance programs, the Internal Revenue Service, the Social Security Administration, and other administrative and regulatory programs.[3]

The projections are made in two major steps--for the nation and then for the states. The national population projections are those of the Census Bureau's "Series II." The national economic projections by industry are based on the population projections and on Bureau of Labor Statistics projections of labor force, unemployment, hours paid per employee, output per paid hour, earnings per unit output, and other components of personal income.

The state projections are made within the framework of the national projections in several steps. Industry earnings in each state are projected by one of two means, depending on whether the industry is classified as "basic" or "service." A state's "basic" industries derive earnings mainly from exports to other states or to other countries. In general, farming, mining, manufacturing, the federal military, and railroad, pipeline, and water transportation are classified as basic industries in all states because the bulk of their output is directed at broad, often national, markets. A state's "service" industries derive earnings mainly from purchases by businesses and households within the state. In general, construction, certain modes of transportation, communication, public utilities, trade, finance, insurance, real estate, business and professional services, and civilian government are classified as service industries in most states. A state's relative growth in earnings mainly depends on the stimulus provided by its basic industries. The basic industries grow in response to increases in the demand for their output by other states. Increased exports generate additional earnings, which stimulate service-industry growth in the exporting states. These industry relationships are reflected in the means of projecting each state's basic- and service-industry earnings.

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[1] The methodology for making state projections is discussed in the November 1980 issue of the Survey of Current Business (U.S., Department of Commerce, Bureau of Economic Analysis Projections 1980, pp. 52-55). This section relies heavily on that discussion.

[2] Earnings are defined as labor and proprietor's income.

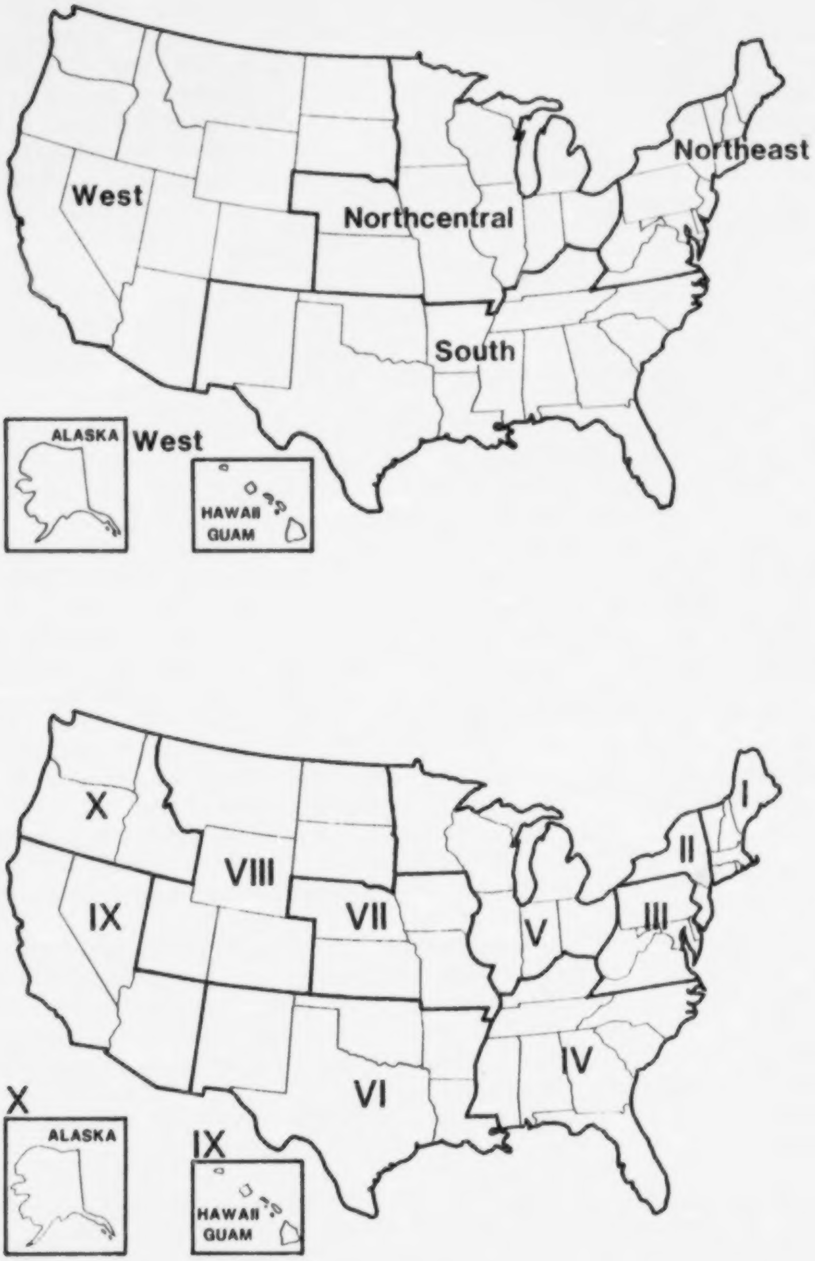
[3] Garnick, Daniel H. 1980. "The Regional Statistics System." Chapter 4 in Modeling the Multiregional Economic System: Perspectives for the Eighties, edited by F. Gerard Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, D. C. Heath.

State earnings in a basic industry are projected by extending into the future the trend in the state's share of the national industry. This share is then multiplied by the national earnings in that industry projected in the national step.

Earnings in each service industry are projected differently. The first step is to project state total earnings in all industries combined. This procedure is initiated by projecting a "multiplier," or ratio of total earnings to earnings in basic industries. First, the trend in the location quotient for each service industry is projected, the location quotient being the ratio of the industry's share of state total earnings to the industry's share of national total earnings. This is multiplied by the industry's share of national total earnings, projected in the national step, to get the industry's share of state total earnings. Industry shares of state total earnings for all service industries are then summed and divided into one to get the projected multiplier. State total earnings are projected by multiplying projected earnings in all basic industries by the projected multiplier. Earnings in each service industry are then projected by multiplying the projected share of state total earnings for each service industry by projected state total earnings.

State employment in each industry is projected by dividing projected state earnings in the industry by projected earnings per employee in the industry in the state. This latter figure is projected by extending the trend of the ratio of state earnings per employee to national earnings per employee in the industry and multiplying the projected ratio by national earnings per employee in the industry as projected by the Bureau of Labor Statistics.

State population in the 15 to 64 age bracket is projected by multiplying projected employment by the projected trend in the ratio of population in this age group to employment. The under age 15 population projection is based on the increase in the 15 to 64 age bracket and the over age 64 population projection is based on the historical trend of the state in attracting retirees.



Appendix 3B: The four major U.S. regions as defined in this study (top) and the Standard Federal Regions (bottom)

APPENDIX 3C: SOUTHERN POPULATIONS: LARGE METROPOLITAN AREAS, 1960-1977^{a}

Metropolitan Area	April 1 1960	April 1 1970	July 1 1977	Absolute Change	Percent Change	Net Migration	Absolute Change	Percent Change	Net Migration
Albuquerque, NM	276	333	402	57	20.6	17	69	20.6	39
Atlanta, GA	1,169	1,596	1,832	426	36.5	233	236	14.8	113
Augusta, GA, SC	230	276	287	46	19.9	12	12	4.2	-8
Austin, TX	267	360	474	93	34.9	51	114	31.6	82
Baton Rouge, LA	300	376	435	76	25.3	21	60	15.9	25
Beaumont-Port Arthur-Orange, TX	331	348	364	17	5.1	-25	16	4.7	-1
Brimingham, AL	747	767	805	21	2.8	-52	38	5.0	5
Charleston-North Charleston, SC	279	336	385	57	20.5	-1	49	14.7	17
Charlotte-Gastonia, NC	444	558	597	114	25.7	45	39	7.0	2
Chattanooga, TN-GA	340	371	403	31	9.1	-7	32	8.7	11
Columbia, SC	261	323	374	62	23.8	24	51	15.9	26
Columbus, GA-AL	218	239	229	21	9.5	-22	-9	-3.9	-28
Corpus Christi, TX	267	285	303	18	6.8	-33	18	6.4	-12
Dallas-Ft. Worth, TX	1,738	2,378	2,673	640	36.8	368	296	12.4	121
Daytona Beach, FL	125	169	214	44	35.2	43	44	26.1	49
El Paso, TX	314	359	435	45	14.4	-29	75	21.0	25
Fayetteville, NC	149	212	231	64	42.9	21	19	9.1	-9
Fort Lauderdale-Hollywood, FL	334	620	864	286	85.7	257	244	39.4	241
Greensboro-Winston-Salem-High Point, NC	622	724	774	102	16.4	20	50	6.9	14
Greenville-Spartanburg, SC	413	473	526	61	14.7	7	53	11.2	25
Houston, TX	1,430	1,999	2,512	569	39.8	317	513	25.7	322
Huntington-Ashland, WV, KY, OH	284	287	297	3	1.0	-24	11	3.7	-1
Huntsville, AL	202	282	291	81	39.9	38	8	2.9	-10
Jackson, MS	221	259	296	38	17.0	(Z)	37	14.2	15
Jacksonville, FL	530	622	694	92	17.4	13	72	11.6	31
Johnson City-Kingsport-Bristol, TN-VA	347	374	408	26	7.6	-11	35	9.3	18
Killeen-Temple, TX	118	160	209	42	35.4	15	49	30.5	23
Knoxville, TN	377	409	449	33	8.7	-7	40	9.7	24
Lakeland-Winter Haven, FL	195	229	277	33	17.1	12	49	21.2	38
Lexinton-Fayette, KY	212	267	294	55	25.8	26	28	10.4	10
Little Rock-North Little Rock, AR	272	323	369	51	18.9	12	46	14.2	20
Louisville, KY-IN	754	867	883	113	15.0	21	16	1.8	-30
Lubbock, TX	156	179	200	23	14.7	-11	21	11.6	3

(continued)

APPENDIX 3C: (continued)

Metropolitan Area	April 1 1960	April 1 1970	July 1 1977	Absolute Change	Percent Change	Net Migration	Absolute Change	Percent Change	Net Migration
Macon, GA	197	227	242	30	15.2	(Z)	15	6.7	-
McAllen-Pharr-Edinburg, TX	181	182	232	1	0.4	-43	51	28.0	16
Melbourne-Titusville-Cocoa, FL	111	230	233	119	106.4	87	3	1.3	-7
Memphis, TN-AR-MS	727	834	886	107	14.7	-4	52	6.3	-5
Miami, FL	935	1,268	1,441	333	35.6	255	173	13.7	147
Mobile, AL	363	377	425	13	3.7	42	48	12.9	21
Montgomery, AL	218	226	254	7	3.4	-18	29	12.6	15
Nahsville-Davidson, TN	597	699	773	102	17.2	30	74	10.5	36
New Orleans, LA	907	1,046	1,133	139	15.4	11	87	8.3	19
Oklahoma City, OK	566	699	769	133	23.5	54	69	9.9	21
Orlando, FL	338	453	593	116	34.3	70	140	30.8	112
Pensacola, FL	203	243	274	40	19.5	(Z)	31	12.9	11
Raleigh-Durham, NC	324	419	487	95	29.4	49	68	16.2	44
San Antonio, TX	736	888	1,025	152	20.7	18	137	15.4	51
Savannah, GA	205	208	215	3	1.6	47	7	3.4	-6
Shreveport, LA	321	336	357	15	4.6	-32	21	6.1	-4
Tampa-St. Petersburg, FL	809	1,089	1,380	279	34.5	253	292	26.8	302
Tulsa, OK	475	549	610	74	15.5	25	61	11.0	30
West Palm Beach-Boca Raton, FL	228	349	477	121	53.0	101	128	36.7	126

Z = Less than 500 - = Zero or Rounds to Zero

Sources: U.S., Department of Commerce, Bureau of Census. 1975. Census of Population and Housing 1970, PHC(2), General Demographic Trends for Metropolitan Areas, 1960 to 1970, Characteristics of the Population, Part 1, United States Summary. Washington, D.C.: Government Printing Office; and U.S. Department of Commerce, Bureau of the Census. 1979. Current Population Reports, Series P-25, No. 810. Washington, D.C.: Government Printing Office.

[a] In thousands, except as indicated. Covers Standard Metropolitan Statistical Areas (SMSA's) with estimated population of 200,000 or more as of July 1, 1977, issued by the Executive Office of the President, Office of Management and Budget. Figures for 1970 include corrections through December 1977. Change measured from April 1, 1960 to April 1, 1970, and from April 1, 1970 to July 1, 1977; minus sign (-) denotes net outmigration or decrease. For definitions and components of SMSA's, and NECMA's, see Appendix II of the U.S. Statistical Abstract, 1979. Data based on Federal-State Cooperative Program estimates; therefore, may not agree with data shown in Appendix II, which is based on federal revenue-sharing estimates.

CHAPTER 4

INDUSTRIAL TRENDS

HIGHLIGHTS

Status and Trends

1. The projected absolute increase in industrial earnings in the Sunbelt over the next 30 years is equal to one-half the total industrial earnings of the entire United States in 1978. The industrial sectors with the greatest potential environmental impacts are:

    - Agriculture, forestry, mining, and construction because of the land area they cover and the extent of disruption of the earth's surface; and

    - Manufacturing and electrical power generation because of the quantity and quality of wastes produced.

2. Each of the sectors which are potential environmental concerns are projected to grow rapidly as measured by earnings in 1972 dollars, manufacturing is projected to increase 240 percent, transportation by 230 percent, construction by 180 percent, mining by 60 percent, and agriculture and forestry by 57 percent.

3. Within the agriculture, forestry, mining, and manufacturing sectors, the following industries present the greatest potential environmental problems for the South based on their current size, projected growth, and production of undesirable wastes.

- Primary and fabricated metals;
- Machinery and transportation equipment manufacture;
- The energy mineral based industries, including coal, petroleum, and gas extraction, and processing into fuels, chemicals, plastics, and rubber;
- Textiles manufacturing;
- Agricultural and forest production;
- Food processing; and
- Pulp and paper manufacture.

- Geographic Areas

4. By 2010, several states are projected to have especially large concentrations of industries with significant potential environmental impacts. These include Texas, Louisiana, North Carolina, Tennessee, Georgia, and Florida.

CHAPTER 4

INDUSTRIAL TRENDS

4.1 INTRODUCTION

Over the next 30 years, the Sunbelt is projectd to experience rapid industrial growth at a rate greater than that for the United States as a whole. Between 1978 and 2010, real dollar earnings[1] and employment are expected to rise 214 and 53 percent respectively, in contrast to 167 and 37 percent for the nation. By 2010, the South will receive 28 percent of total U.S. earnings and provide 30 percent of total U.S. jobs. Although such growth will be the key to increased incomes and rising populations in southern communities long subject to incomes substantially below average, outmigration, and even population decline, it will also bring significant environmental pressures. The magnitude of the potential environmental change in the Sunbelt is indicated by the fact that the projected absolute increase in industrial earnings in the region over the next 30 years is equal to one-half the total industrial earnings of the entire United States in 1978. The current size, concentration, and projected growth of certain industrial sectors in the South are of special concern because of the magnitude of their potential environmental impacts. These include manufacturing because of its rapid growth and the volume of wastes generated; mining because of the disruption of the earth's surface and disposal of spoils; and agriculture and forestry because of the tremendous volumes of sediment, often containing nutrients and pesticides, washed into water bodies by the exposure and working of soil surfaces.

This chapter reviews projections of industrial trends for the Sunbelt. It examines and compares current size and projected growth of the major industrial sectors. Its purpose is to identify: (1) those industrial sectors that have the potential to significantly affect environmental quality in the Sunbelt over the next 30 years and (2) those states where the greatest impacts of each of these sectors are likely to be felt. The results of this analysis are used to identify some of the key industrial driving forces to be further investigated in the chapters of Volume II.

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[1] As used by the Bureau of Economic Analysis (BEA), earnings refers to labor and proprietors' income.

4.2 METHODOLOGY

The analysis is based on the Bureau of Economic Analysis (BEA) projections of earnings by state by industry.[1] Earnings, rather than employment projections, are used to indicate the size and growth of an industry. Change in earnings is usually a more accurate indicator of output than is change in employment because changes in output per employee are typically reflected in earnings but not in employment changes.

Although these projections provide valuable indicators of industrial change, they do have a number of limitations for the purpose of identifying sectors with the potential to create environmental change. First, earnings are not accurate measures of either changes in output or production of wastes or residuals. They accurately measure changes in output only where labor costs per unit of output remain constant and they are poor measures of production of wastes because residual production per dollar of earnings varies dramatically across industries and across time.

Second, the projections have all the limitations, discussed in Chapter 3, inherent in the assumptions and methodology used to make them. They do not anticipate changes in the future, but rather describe a future based on past trends. Inevitable inaccuracies become greater as the projections are progressively disaggregated to more specific industries and geographic areas. The projections in this chapter are, in certain cases, at odds with projections for a given industry presented in subsequent chapters, where more attention could be focused on trends and trend changes in a specific industry. As an example, the BEA projections predicted petroleum and gas mining earnings would increase by only 28 percent in Region 6 between 1978 and 2010. Subsequent to 1978, the oil and gas industry entered a boom period in Region 6 unpredictable from pre-1978 trends. Rig counts, not directly comparable to earnings but certainly indicative, increased by 78 percent over the short period between November, 1978, and September, 1981 (Oil and Gas Journal, 1978, p. 212; and 1981, p. 231). While it is uncertain whether this rapid growth rate is a short-term phenomenon or will persist in the long-term, it is clear that unforeseen dramatic changes in trends do occur.

Third, the greatest industry detail available in the projections is the two-digit Standard Industrial Classification (SIC) code.[1] In general the two-digit SIC codes combine two or more industries with different environmental consequences, both in quality and in quantity of residuals. For example, the two-digit SIC 31 (leather and leather products) includes the three-digit SIC 311 (leather tanning and finishing), which has the potential to produce serious environmental impacts, plus five other three-digit categories such as SIC 314 (footwear) and SIC 317 (handbags and other personal leather goods), which do not. It is impossible to tell from the BEA projections which of these three-digit industries predominate in any given geographic area, and thus whether the presence of leather and leather products establishments is likely to create environmental problems.

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[1] A discussion of the assumptions and methodology used in these projections is found in Section 3.2 and in Appendix 3-A of Chapter 3.

Fourth, the greatest level of geographic detail in the projections is the state. A given industry is usually not distributed uniformly over a state but is more or less concentrated in selected substate regions. Two errors can result from this fact:

(1) The BEA projections tend to give the impression that an entire state is affected by a given industry when in fact the affected area may be relatively small; and

(2) A low level of activity in the state as a whole may indicate the industry is not an important environmental concern when in fact the industry may be so concentrated it could create serious problems in those areas.

Finally, the fact that individual states vary greatly in area may distort conclusions about the severity of a potential problem in a given state drawn from the size of an industry in the state. For example, environmental problems based on the magnitude of earnings in an industry may tend to be overestimated in Texas and underestimated in South Carolina simply because of the land area differences of these states.

In sum, the BEA projections do have a number of limitations. However, they are one of a very few sets of systematic, consistent, comparable, long-range projections for all states in the region in considerable industry detail. One may argue with individual values, but the overall trends remain plausible. They are highly useful for the purpose of this chapter, which is not to predict accurately the future size of a given industry in a given state, but to identify those sectors with the greatest potential for creating economic and environmental change in the South.

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[1] The Standard Industrial Classification (SIC) code is a hierarchical system that classifies industrial establishments by their principal product. (See U.S., Exec. Off. of President, OMB, 1972 and 1977.) The greatest detail is available at the four digit level. Related four digit industries are combined into a single three-digit classification, related three-digit industries are combined in a two-digit classification, and so on. For example, manufacturing, primary metals, iron and steel foundries, and gray iron foundries have the codes SIC 3, SIC 33, SIC 332, and SIC 3321, respectively.

4.3 INDUSTRIAL TRENDS

Industrial earnings in real dollars[1] are projected to grow more rapidly between 1978 and 2010 in the Sunbelt (214 percent) than in the United States as a whole (167 percent) or any other major U.S. region (U.S., Dept. of Commerce, BEA, 1980). In absolute terms, earnings in the Sunbelt are projected to grow from 211 billion dollars to 661 billion, a change equal to about one-half the total earnings of the United States in 1978. Trends in the two Sunbelt regions are similar. Earnings in Region 4 are projected to grow from 123 billion to 381 billion dollars (209 percent) and in Region 6 from 87 to 280 billion dollars (221 percent). The magnitude of these changes is large both absolutely and relatively. Although they clearly offer the potential for significant benefits, as discussed in the previous chapter, they also indicate the possibility of significant environmental change caused by increased industrial activity.

When changes in industrial earnings are broken down by major industrial sector, it is apparent that almost all sectors are projected to grow more rapidly in the South than in the United States (Tables 4-1 and 4-2). Among the three sectors of manufacturing, mining, and agriculture--those "basic" sectors supplying the impetus for growth in the remaining "service" sectors--earnings in manufacturing in both regions 4 and 6 and in mining in Region 4 are growing more rapidly than in the total U.S. Agriculture in both regions is projected to grow at a similar rate and mining in Region 6 is projected to grow at a slower rate than the corresponding U.S. sectors. From these figures it is clear that growth in manufacturing, and to a lesser extent mining, is the key driving force behind the projected high growth rate of total Sunbelt earnings relative to total U.S. earnings. Projected growth rates for the remaining "service" industries of transportation, construction, wholesale and retail trade, services, government, and finance, insurance, and real estate vary, but are all more rapid than their corresponding U.S. industries.

The structure of the Sunbelt economy, or the relative importance of individual sectors to total Sunbelt earnings, is also projected to change. Some of these changes reflect trends in the United States economy as a whole:

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[1] All earnings figures in this chapter are expressed in terms of constant 1972 dollars.

TABLE 4-1: REGION 4 SECTOR EARNINGS
(millions of 1972 dollars)

Sector	1969	1978	1990	2000	2010	% change 1978-2010	
						Region 4	U.S.
All Industry	86,137	123,318	205,565	285,002	380,641	209	167
Agriculture, Forestry, Fisheries	3,708	4,260	4,763	5,539	6,522	53	59
Mining	625	1,562	3,523	4,815	6,206	298	171
Construction	5,823	7,743	13,162	18,080	24,030	210	172
Manufacturing	23,169	31,077	51,518	71,437	95,310	207	121
Transportation, Communication, and Public Utilities	5,689	9,446	16,427	23,278	31,548	234	177
Wholesale Trade	5,121	8,054	13,333	18,158	23,913	197	151
Retail Trade	9,465	13,030	21,447	29,564	39,265	201	154
Finance, Insurance, and Real Estate	4,174	6,523	11,934	17,249	23,687	263	204
All Service	12,306	18,725	35,201	51,896	72,289	286	237
All Government	15,674	22,311	33,337	43,780	56,314	152	128

Source: U.S., Dept. of Commerce, BEA, 1980.

TABLE 4-2: REGION 6 SECTOR EARNINGS
(millions of 1972 dollars)

Sector	1969	1978	1990	2000	2010	% change 1978-2010	
						Region 6	U.S.
All Industry	56,310	87,408	148,831	207,878	280,152	221	167
Agriculture, Forestry, Fisheries	2,114	2,200	2,802	3,142	3,609	64	59
Mining	2,445	5,253	6,852	7,137	7,643	45	171
Construction	4,155	7,288	10,878	14,282	18,545	154	172
Manufacturing	11,226	16,746	32,549	48,373	67,352	302	121
Transportation, Communication, and Public Utilities	4,367	7,372	12,704	17,861	24,140	227	177
Wholesale Trade	3,744	6,565	11,054	15,134	20,032	208	151
Retail Trade	6,416	9,407	15,309	20,991	27,948	197	154
Finance, Insurance, and Real Estate	2,870	4,747	8,825	12,792	17,691	273	204
All Service	8,301	13,283	25,611	38,246	53,945	306	237
All Government	10,455	14,168	21,616	29,058	38,103	169	128

Source: U.S., Dept. of Commerce, BEA, 1980.

- Services and finance, insurance, and real estate are increasing their shares;

- Agriculture and government are decreasing their shares; and

- Wholesale trade, retail trade, transportation, and construction are maintaining their shares.

Other structural changes in the Sunbelt are in contrast to United States patterns. Nationally, the share of total earnings derived from manufacturing is projected to decline from 26 percent to 22 percent over the period 1978 to 2010. In the Sunbelt, manufacturing in Region 4 is projected to maintain its share of total earnings at around 25 percent and in Region 6 to increase its share from 19 percent to 24 percent. At the national level, mining is expected to maintain its 1.6 percent share of total earnings. However, mining earnings in Region 4 will increase from a below average 1.3 percent share to the national average. In Region 6, where mining has contributed a relatively large 6.0 percent of total earnings, mining's share will decrease to 2.7 percent. These projected trends again emphasize the growing importance of the Sunbelt as one of the nation's most important manufacturing regions and, in general, the decline of primary, rural activities such as agriculture, forestry, and mining to its industrial base.

The sectors in the Sunbelt with the greatest potential environmental impacts are (1) agriculture, forestry, and mining because of the land area they cover and the extent to which they modify the earth's surface and (2) manufacturing and electrical power generation because of the wastes produced. Because of this potential impact, these sectors, with the exception of electrical power generation and forestry, are examined in greater detail in the next section in order to identify key industries within these sectors with the potential to impact the Southern environment. Electrical power generation and forestry could not be separated out of the BEA projections in enough detail to be useful; they are, however, considered in more detail in Chapters 7 and 9. Construction and transportation do create environmental impacts, but much of their impact is limited to the period of construction itself or is closely related to general urbanization. Wholesale and retail trade; finance, insurance, and real estate; services; and government create few impacts in themselves that are not related to the urbanization process and population growth (see Chapter 3).

4.4 GROWTH OF AGRICULTURE, MINING, AND MANUFACTURING INDUSTRIES

Within the three sectors of agriculture, mining, and manufacturing, some industries have the potential to create more serious environmental impacts than others. This section provides a broad overview of the size, growth, and locational patterns of the most environmentally significant of these industries in the Sunbelt.

The analysis concentrates on 16 two-digit industries within the one-digit agriculture, mining, and manufacturing sectors. These sectors were identified on the basis of their size, their projected growth rate, and the severity of their associated environmental problems (Tables 4-3 and 4-4). The industries projected to grow most rapidly (greater than 250 percent) in both regions include: stone, clay, and glass products; fabricated metals; machinery; instruments; rubber; and coal mining. To these rapidly growing common industries are added petroleum refining in Region 4 and primary metals, chemicals, and metal mining in Region 6. Of the industries projected to grow most rapidly, only machinery is currently also a large (earnings greater than 2 billion dollars) industry in either region. Other large, but not among the most rapidly growing, industries include transportation equipment, food and kindred products, textiles, apparel, chemicals, and agriculture in Region 4 and petroleum mining and agriculture in Region 6. From this list of large or rapidly growing industries, instrument and apparel manufacturing are not considered further because of their relatively low production of wastes. Of the remaining smaller and less rapidly growing industries--nonmetal mining, leather products, lumber products, furniture and fixtures, tobacco products, and printing and publishing--only nonmetal mining was considered to pose significant enough environmental concerns region-wide to be included in the analysis.

The analysis in this section provides a broad overview of projected environmentally significant industrial change in the Sunbelt.[1] An extended discussion of the projected trends and the character of the environmental problems created by these sectors is contained in Volumes II and III. The primary data underlying the analysis are: (1) the projected growth in industrial earnings over time by detailed sector for Regions 4 and 6 contained in Tables 4-3 and 4-4; and (2) 1978 and projected 2010 earnings by state contained in Appendix 4A and summarized in Table 4-5.

4.4.1 The Industrial Core Manufacturing Industries

The primary metals, fabricated metals, machinery, and transportation equipment manufacturing industries represent the traditional core of a manufacturing economy. All of these industries are

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[1] The information on environmental problems associated with each industry is derived from statistics presented in Volumes II and III and the following sources: Center for Environmental Reporting, 1979; U.S. Water Resources Council, 1978; Nemerow, 1978; U.S., EPA, ORD, Strategic Analysis Group, 1980; and U.S., EPA, Off. of Air, Noise, & Radiation, 1980.

TABLE 4-3: REGION 4 EARNINGS IN MANUFACTURING, MINING, AND AGRICULTURE (millions of 1972 dollars)

Sector (SIC codes)	1969	1978	1990	2000	2010	% change 1978-2010
Manufacturing Durables	10,318	14,752	26,830	38,740	52,991	259
Lumber Products (24)	1,056	1,509	2,262	2,930	3,748	148
Furniture and Fixtures (25)	932	1,123	1,778	2,436	3,214	186
Stone, Clay and Glass Products (32)	766	1,134	2,042	2,941	4,015	254
Primary Metals (33)	1,057	1,590	2,730	3,804	5,095	220
Fabricated Metals (34)	1,131	1,764	3,307	4,811	6,593	273
Machinery (35 and 36) (including electric)	2,807	4,651	9,390	14,131	19,814	326
Transportation Equipment (37) (including motor vehicles)	1,700	2,242	3,887	5,513	7,455	233
Instruments (38)	192	395	881	1,423	2,076	426
Miscellaneous Manufacturing (39)	245	343	553	751	981	186
Manufacturing Nondurables	12,851	16,325	24,688	32,697	42,319	159
Food and Kindred Products (20)	1,871	2,388	3,278	4,148	5,156	116
Tobacco Products (21)	412	504	562	646	751	49
Textile Mill Products (22)	4,099	4,391	5,780	7,222	8,962	104
Apparel and Other Fabricated (23)	1,833	2,205	3,279	4,271	5,435	146
Paper and Allied Products (26)	1,117	1,602	2,528	3,337	4,326	170
Printing and Publishing (27)	821	1,139	2,033	2,846	3,805	234
Chemicals and Allied Products (28)	1,840	2,509	4,230	5,816	7,738	208
Petroleum Refining (29)	57	124	276	412	571	360
Rubber and Miscellaneous Plastics (30)	514	1,191	2,475	3,725	5,268	342
Leather and Leather Products (31)	221	231	247	275	307	33
Agricultural Production (01 & 02)	3,708	4,260	4,763	5,539	6,522	53
Mining	625	1,562	3,523	4,815	6,206	297
Coal Mining (11 & 12)	298	1,039	2,764	3,940	5,184	399
Crude Petroleum and Natural Gas (13)	67	152	290	310	336	121
Metal Mining (10)	25	17	27	30	34	100
Nonmetal Mining, excluding fuels (14)	205	319	442	535	652	104

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

TABLE 4-4: REGION 6 EARNINGS IN MANUFACTURING, MINING, AND AGRICULTURE (millions of 1972 dollars)

Sector (SIC codes)	1969	1978	1990	2000	2010	% change 1978-2010
Manufacturing Durables	6,313	9,462	19,820	30,398	43,066	355
Lumber Products (24)	443	707	1,130	1,527	2,007	184
Furniture and Fixtures (25)	217	242	387	536	713	195
Stone, Clay and Glass Products (32)	445	715	1,334	1,941	2,676	274
Primary Metals (33)	495	881	1,846	2,939	4,236	381
Fabricated Metals (34)	771	1,512	3,278	5,123	7,346	386
Machinery (35 & 36)(including electric)	1,803	3,545	8,577	13,621	19,689	455
Transportation Equipment (37) (including motor vehicles)	1,606	1,451	2,482	3,519	4,729	226
Instruments (38)	147	248	499	772	1,100	344
Miscellaneous Manufacturing (39)	108	161	289	420	571	255
Manufacturing Nondurables	4,913	7,284	12,729	17,975	24,287	233
Food and Kindred Products (20)	1,194	1,556	2,278	2,978	3,797	144
Tobacco Products (21)	1	1	1	1	1	0
Textile Mill Products (22)	87	94	162	215	279	197
Apparel and Other Fabricated (23)	459	617	1,047	1,452	1,924	212
Paper and Allied Products (26)	422	647	1,151	1,632	2,209	241
Printing and Publishing (27)	519	717	1,292	1,844	2,507	250
Chemicals and Allied Products (28)	1,155	1,859	3,792	5,759	8,164	338
Petroleum Refining (29)	797	1,195	1,832	2,374	3,018	153
Rubber and Miscellaneous Plastics (30)	198	470	1,062	1,588	2,236	376
Leather and Leather Products (31)	75	95	114	132	152	60
Agricultural Production (01 & 02)	2,114	2,200	2,802	3,142	3,609	64
Mining	2,445	5,253	6,852	7,137	7,643	45
Coal Mining (11 & 12)	7	40	205	337	484	1,110
Crude Petroleum and Natural Gas (13)	1,582	4,682	6,078	6,010	6,104	28
Metal Mining (10)	79	164	283	432	607	270
Nonmetal Mining, excluding fuels (14)	145	151	285	358	448	197

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

TABLE 4-5: STATES PROJECTED TO HAVE HIGH EARNINGS IN 2010[a]

Industry	AL	FL	GA	KY	MS	NC	SC	TN	AR	LA	NM	OK	TX
Stone, Clay, and Glass		o				o		o					x
Primary Metals	x		o	o				o		o			x
Fabricated Metals		o				o		o					x
Machinery (including electrical)		o		o		o		o					x
Transportation Equipment (including motor vehicles)		o	o	o				o		o			x
Food and Kindred Products		o	o			o		o					x
Textile Mill Products			x			x	x						
Paper and Allied Products	o		x			o		o	o	o			x
Chemicals and Allied Products						o	o	o		x			x
Petroleum Refining										o			x
Rubber and Miscellaneous Plastics						o	o	o					x
Agriculture		x	o	o		x			o				x
Coal Mining	o			x									
Crude Petroleum and Natural Gas										o		o	x
Metal Mining											x		
Nonmetal Mining		o	o										o

Source: Calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] "x" indicates a leading producer, "o" indicates other states with at least 8 percent of the southern industry earnings.

projected to become increasingly important in the Sunbelt, and all produce environmentally significant waste products.

A. Primary Metals

The primary metal industry (SIC 33) includes factories that smelt and refine ferrous or nonferrous ores, that roll, draw, or alloy refined metals, that cast molten metals, and that manufacture nails, spikes, wire, or cable. The industry is one of the largest point sources of carbon monoxide, sulfur oxides, and particulates and a significant point source of airborne trace elements, particularly lead. It is the largest manufacturing producer of water-borne suspended solids and industrial solid waste, and one of the largest industrial producers of hazardous wastes. In addition, it generates large amounts of wastewater containing oil and grease and waste heat[1] (see Chapter 14).

Primary metal earnings in 1978 were 1.6 billion dollars in Region 4 and 0.9 billion dollars in Region 6. These figures indicate that primary metals ranked ninth and sixth among manufacturing industries in regions 4 and 6, respectively, and that the South produced 13 percent of the total U.S. industry earnings. Major primary metal centers include the Gulf Coast, dominated by aluminum with some tin, zinc, uranium, and manganese and a more diversified northern Alabama-Kentucky-Tennessee Valley center producing iron and steel, aluminum, uranium, tungsten, manganese, lithium, and hafnium/zirconium (Oxford Regional Economic Atlas, 1975). These concentrations indicate the importance of plentiful energy supplies--coal in Alabama and Kentucky, oil and gas in Texas and Louisiana, and electric power in the Tennessee Valley.

Industry earnings are projected to grow by 220 percent in Region 4 and 381 percent in Region 6. This growth represents 24 percent of the total U.S. increase in earnings and results in the Sunbelt's share of the U.S. industry increasing to 20 percent by 2010. At that time, the industry is projected to be concentrated in Alabama and Texas with secondary concentrations in Georgia, Kentucky, Tennessee, and Louisiana.

B. Fabricated Metals

The fabricated metals industry (SIC 34) produces fabricated structural metal products, metal forgings and stampings, and metal cans, tinware, hand tools, and hardware. Waterborne wastes are not large in volume but are often highly toxic with large concentrations of acids, heavy metals, oil and grease, and waste heat. Airborne wastes include heavy metals, hydrocarbons, and particulates. The industry is also a significant producer of hazardous wastes (see Chapter 15).

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[1] As discussed in Chapter 14, industrial activities can generate polluted wastewaters, but the amount of pollution discharged to the environment will depend on the level of wastewater treatment applied.

In 1978, the industry produced earnings of 1.8 billion dollars in Region 4 and 1.5 billion in Region 6; it ranked seventh and fourth in earnings among all manufacturing industries in the respective regions. The industry was widely distributed throughout metropolitan areas in the South, with the largest concentration in Houston (Oxford Regional Economic Atlas, 1975). The industry is projected to grow between 1978 and 2010 by 273 percent and 386 per cent, respectively, in regions 4 and 6. These changes represent 33 percent of the total U.S. increase in earnings and result in the Sunbelt's share of the U.S. industry earnings increasing from 17 to 27 percent. The industry is projected to continue to be widespread, with Texas remaining the largest producer but with substantial shares also to be found in Florida and Tennessee.

C. Machinery

The machinery manufacturing industry (SIC 35 and 36) produces all types of machinery including electrical and communications equipment. Machinery manufacturing produces airborne criteria pollutants and trace metals and wastewaters containing suspended solids, heavy metals, oils and solvents, and pH-altering chemicals. Further, it produces significant quantities of hazardous wastes.

In terms of earnings, machinery is the dominant manufacturing industry in the Sunbelt and is projected to become even more dominant in the future. In 1978, the industry was the largest source of manufacturing earnings in both regions 4 and 6, producing, respectively, 4.7 and 3.5 billion dollars of earnings. In spite of the size, the Sunbelt received only 16 percent of total U.S. machinery earnings. Within the Sunbelt, machinery manufacture was widely distributed but with concentrations in Houston, Dallas/Ft. Worth, Oklahoma City, and Louisville (Oxford Regional Economic Atlas, 1975). The rate of earnings growth between 1978 and 2010 is projected to be the most rapid of any manufacturing sector in Region 6 (455 percent) and the fourth most rapid in Region 4 (326 percent). This growth, representing 33 percent of the total projected U.S. growth in machinery earnings, would bring the Sunbelt share of U.S. machinery earnings to 27 percent. Machinery's share of total Sunbelt manufacturing earnings is projected to be even more dominant in 2010 than it was in 1978. Texas is projected to produce one-third of all machinery earnings in 2010, but with all other states besides New Mexico--especially Florida, Kentucky, North Carolina, and Tennessee--having significant shares.

D. Transportation Equipment

The transportation equipment industry (SIC 37) produces motor vehicles, aircraft, ships and boats, railroad equipment, and missile and space hardware. These manufacturing processes generate criteria air pollutants (especially hydrocarbons) and trace metals (especially asbestos and cadmium). It is also a large manufacturing water user, and generates wastewaters containing oils, solvents, acids, suspended solids, painting chemicals, heavy metals, and waste heat. In addition, it is a significant producer of hazardous wastes.

In 1978, the transportation equipment industry was the fifth largest source of manufacturing earnings in both regions (2.2 billion dollars in Region 4 and 1.5 billion dollars in Region 6), but represented only 12 percent of U.S. transportation equipment earnings. Major centers of motor vehicle and aerospace manufacturing were in Dallas-Ft. Worth, Atlanta, and the east coast of Florida. Ship building was concentrated along the Gulf Coast of Texas, Louisiana, and Mississippi, and the South Atlantic Coast (Oxford Regional Economic Atlas, 1975). Projected earnings growth rates (233 percent in Region 4 and 226 percent in Region 6) are similar to the overall manufacturing earnings growth rate for the Sunbelt and will bring the Sunbelt's share of U.S. earnings to 16 percent. Texas is projected to have the greatest share of earnings with Florida, Georgia, Kentucky, Tennessee, and Louisiana also having large shares.

4.4.2 The Fuel Based Industries

The fuel based industries include coal mining, oil and gas mining, petroleum refining, chemical manufacture, and rubber manufacture. They are a highly related set of industries, with the result that their locational patterns are often interdependent. The location of large quantities of the nation's coal, oil, and gas resources in the Sunbelt means these industries play an especially prominent role in the Sunbelt economy.

A. Coal Mining

The coal mining industry (SIC 11 and 12) includes the mining, cleaning, and washing of anthracite, bituminous coal, and lignite. In coal mining districts the industry contributes to water pollution problems because of high suspended solids and dissolved acids from spoils runoff and acid mine drainage. Severe surface disruption, the possibility of subsidence, and the problem of spoils disposal accompany many mining operations. (See Chapter 6 for further discussion of trends and environmental problems.)

In 1978, 38 percent of U.S. coal mining earnings were received in the Sunbelt, 1.0 billion dollars in Region 4 and 40 million dollars in Region 6. Seventy-three percent of this production was concentrated in eastern Kentucky, with an additional 16 percent in northern Alabama. The lignite resources of southeastern Texas and subbituminous coal in New Mexico were just coming into significant production during the past decade. Earnings in the industry are projected to grow by 425 percent in the Sunbelt as a whole between 1978 and 2010 with 65 percent of this growth occurring in Kentucky and most of the remainder in Alabama and Tennessee.

B. Petroleum and Gas Development

The petroleum and natural gas mining industry (SIC 13) includes the exploration and production of these minerals plus the recovery of oil from heavy oil bearing sands and from oil shale. The industry is one of the largest point sources of airborne hydrocarbons. It produces large quantities of highly saline wastewater plus liquid hydrocarbon wastes. Locally, surface disturbance to lands occurs and in some locations oil and gas mining can produce land subsidence if produced water is not reinjected (see Chapter 6 for further details).

Seventy-two percent of U.S. earnings in this industry occurred in the Sunbelt (2.6 billion dollars in Region 4 and 4.7 billion dollars in Region 6). The primary areas of production include, Texas, Louisiana, and Oklahoma; these three states produced 96 percent of Sunbelt total earnings in the industry. The BEA projections indicate earnings for the southern region are expected to grow by only 33 percent, but, as indicated earlier, high drilling rates since 1978 put this projection in doubt. Seventy-five percent of this increase is projected to occur in Texas, Louisiana, and Oklahoma, but these projections do not include potential new areas such as in Alabama or along the South Atlantic Coast.

C. Petroleum Refining

The petroleum refining industry (SIC 29) consists of petroleum refining itself plus the manufacture of paving and roofing materials and the compounding of lubricating oils and greases. It produces noxious odors and is a major stationary source of airborne carbon monoxide, hydrocarbons, sulfur oxides, and lead. The water pollutants it generates include biochemical oxygen demand (BOD), solids, hydrocarbons, and waste heat. Further, it is one of the largest sources of hazardous wastes in Region 6 (see chapters 6 and 15 for further details).

Petroleum refining earnings in 1978 in the Sunbelt, like petroleum production, were concentrated in the three state Texas/

Louisiana/Oklahoma area of Region 6 (96 percent of Region 6 earnings of 1.2 billion dollars). Region 4 earnings were only 0.1 billion dollars. The industry ranked sixth in earnings among manufacturing sectors in Region 6 but only eighteenth in Region 4. The Sunbelt produces 36 percent of U.S. earnings in refining indicating it has a smaller share of U.S. refining earnings than it does of petroleum and gas mining earnings.

Between 1978 and 2010, industry earnings are projected to grow 153 percent in Region 6, where the industry is large, and 360 percent in Region 4, where it is currently small. This growth represents 44 percent of total U.S. growth in refining earnings. The greatest absolute increases are projectd to continue to be in the tri-state Texas/Louisiana/Oklahoma area of Region 6, but Kentucky is also projected to see a significant increase.

D. Chemicals and Allied Products

The chemicals industry (SIC 28) produces basic chemicals such as acids, alkalies, and organics; chemicals to be used in further manufacturing, such as synthetic fibers, plastics, and pigments; and finished chemicals such as drugs, soaps and detergents, paints, fertilizers, and explosives. The chemicals industry is by far the nation's largest producer of hazardous wastes; estimates typically range around 60 percent. It is a major generator of wastewater containing heat, BOD, hydrocarbons, nitrogen and phosphorus, and heavy metals. In addition, it is one of the largest point sources of airborne hydrocarbons, carbon monoxide, sulfur oxides, and heavy metals (see Chapter 7 for a further discussion).

The chemical industry is one of the most important industrial sectors to the South. In 1978 it ranked third in earnings among manufacturing sectors in Region 4 (2.5 billion dollars) and second in Region 6 (1.9 billion dollars). Twenty-nine percent of U.S. earnings in the industry accrued to the South. The largest concentration of the industry in the Sunbelt was located in Texas and Louisiana with an emphasis on organics and plastics (see Chapter 7). Smaller concentrations were found in Tennessee (inorganics and plastics), North Carolina and South Carolina (plastics), and Florida (agricultural chemicals).

This already large industry is projected to grow rapidly between 1978 and 2010 (208 percent in Region 4 and 338 percent in Region 6). In absolute terms, the projected growth of industry earnings (11.5 billion dollars) ranks second only to machinery among manufacturing sectors in the Sunbelt. These figures represent 40 percent of total U.S. growth in this sector and indicate the Sunbelt's share of U.S. industry earnings is projected to grow to 40 percent in 2010. In addition, this growth is projected to be highly concentrated, with 51 percent occurring in Louisiana and

Texas and another 28 percent occurring in the Carolinas and Tennessee.

E. Rubber and Miscellaneous Plastics

The rubber industry (SIC 30) includes the manufacture of tires, footwear, floor covering, mechanical rubber goods, and plastic products from natural, synthetic, and reclaimed rubber and rubber-like products. It is a large national source of hazardous wastes and industrial solid wastes. It produces airborne emissions as well as waterborne BOD, solids, acids and bases, hydrocarbons, and highly odoriferous chemicals that can make water unpalatable at extremely low concentrations.

In 1978, the industry ranked eleventh in manufacturing earnings in Region 4 (1.2 billion dollars) and thirteenth in Region 6 (0.5 billion dollars). These values represent 22 percent of the total U.S. industry. Although the industry is not among the largest manufacturing sectors in the South, it is projected to be among the most rapidly growing over the period 1978 to 2010 (third in Region 4 at 342 percent and fourth in Region 6 at 376 percent). Earnings have been and are projected to continue to be concentrated in Texas, the Carolinas, and Tennessee.

4.4.3 Textiles

The textile industry (SIC 22) includes the preparation of natural and synthetic fibers, the dyeing and finishing of these fibers, their manufacture into yarn, thread, and twine, and the manufacture of fabrics and carpets. In areas of industry concentration, it is a significant point source of airborne hydrocarbons and its wastewaters contain BOD, solids, coliforms, acids and bases, and waste heat. The processing of cotton fibers has been associated with byssinosis, or brown lung, a respiratory disease caused by inhaling cotton dust. However, the major environmental concerns are the rapidly changing quantities of metals and hazardous chemicals, some with potential carcinogenic properties, that are used in textile processing. These chemicals and metals may create both water pollution and hazardous waste treatment and disposal problems (see Chapter 8 for further details).

The industry is and will continue to be very important in Region 4. In 1978, it was the second largest manufacturing source of earnings in Region 4 (4.7 billion dollars). The South produced more than two-thirds (68 percent) of total U.S. earnings in this industry, with 84 percent of this concentrated in the three states of North Carolina, South Carolina, and Georgia. Although the Region 4 industry is projected to grow by only 104 percent through 2010, this would represent 77 percent of total U.S. growth in the industry and a doubling of one of the largest manufacturing sectors in the Sunbelt. Most (83 percent) of this growth is projected to occur in the three states dominating current production. Because of the current size, projected absolute growth, localization, and toxicity and rapidly changing character of wastes, this industry is judged to be environmentally important in the Sunbelt.

4.4.4 Stone, Clay, and Glass Products

The stone, clay, and glass products industry (SIC 32) consists of the manufacture of glass, cement, structural clay products such as bricks, concrete, and gypsum products, and abrasives and asbestos products. It is a major point source of airborne particulates and sulfur oxides due both to high fossil fuel use and to the handling, grinding, blending, and processing of the raw materials. The industry generates wastewaters high in suspended and dissolved solids, pH altering substances, and waste heat. The asbestos subindustry produces highly carcinogenic asbestos wastes.

In 1978, earnings in the stone, clay, and glass industry ranked thirteenth (1.1 billion dollars) in Region 4 and ninth in Region 6 (0.7 billion dollars) among all manufacturing industries. The raw materials used by the industry are typically low-valued, heavy, and bulky. Because the raw materials are difficult to transport and are found in many locations throughout the Sunbelt, production is widely distributed among the states. The industry is expected to grow over the period 1978 to 2010 at the rate of 254 percent in Region 4 and 274 percent in Region 6. Growth in earnings will be widely distributed throughout the Sunbelt, with the geographical distribution of earnings in 2010 resembling that in 1978.

4.4.5 Agriculture and Forest Based Industries

The environmentally significant agriculture and forest based industries include agricultural production, forest production, food and kindred products manufacture, and pulp and paper manufacture. These industries, with the exception of forest production, are discussed below. Forest production, for which disaggregated BEA data and projections were not available, is discussed in Chapter 9.

A. Agricultural Production

The agricultural production industry (SIC 01 and 02) includes the production of both crops and livestock. Water runoff from exposed soil surfaces produces serious environmental problems. It contributes to soil erosion and the deterioration of the productive land base. Runoff from agricultural lands is by far the largest source of waterborne suspended solids, dissolved nutrients such as nitrogen and phosphorus, and toxic pesticides, and is one of the largest sources of BOD and coliforms. Tillage, wind erosion, open field burning, orchard heating, and pesticide application also contribute to air pollution problems.

Earnings from the industry in 1978 were 4.3 billion dollars in Region 4 and 2.2 billion dollars in Region 6; these values represent 28 percent of U.S. agricultural earnings. States with the greatest shares of Sunbelt earnings include Florida, Georgia, North Carolina, Arkansas, and Texas. Growth in total agricultural earnings over the period 1978-2010 is projected to be slow relative to growth in total Sunbelt earnings--53 percent in Region 4 and 64 percent in Region 6. However, some states, such as Kentucky, Louisiana, Oklahoma, and New Mexico, are projected to see earnings growth of 80 percent or more, primarily through the conversion of forest and rangeland to cropland. Such conversion, by exposing more soil surface to wind and water erosion and increasing the rate of application of nutrients and pesticides, will add significantly to the environmental problems produced by agriculture.

B. Food and Kindred Products

The food and kindred products industry (SIC 20) manufactures or processes foods and beverages for human consumption, vegetable and animal oils and fats, and prepared feeds for livestock. Nationally, the industry is the second largest point source of BOD behind municipal wastewater and also produces large quantities of waterborne nutrients, suspended solids, coliforms, and oil and grease. Some processing plants also produce disagreeable odors.

In 1978, earnings from the industry ranked fourth (2.4 billion dollars) and third (1.6 billion dollars) among all manufacturing sectors in regions 4 and 6, respectively. The Sunbelt industry had a share of the national industry (22 percent) very similar to the Sunbelt share of national agricultural production (28 percent). The industry was widely dispersed, but with concentrations in Texas, along the South Atlantic Coast from North Carolina to Florida, and in Tennessee.

Industry earnings are projected to grow more rapidly than agricultural production but less rapidly than Sunbelt industry as a whole--116 percent in Region 4 and 144 percent in Region 6. Growth rates are projected to be relatively uniform among the 13 Sunbelt states. Absolute growth, however, is projected to be greatest in regions of current high production (Texas, the South Atlantic Coast, and in Arkansas).

C. Paper and Allied Products

The paper and allied products industry (SIC 26) manufactures pulp, paper and paperboard, and bags, boxes, and envelopes. Nationally, the paper and allied products industry is the third largest point source of BOD, behind municipal wastewater and food processing, and a large point source of suspended solids and coliform bacteria. In addition, it discharges waste heat and its wastewaters contain pH altering chemicals used in processing. Locally, pulp mills can have a substantial impact on water quality. Pulping produces significant quantities of carbon monoxide, fine particulates, and odoriferous sulfur bearing compounds. The industry as a whole is a significant producer of industrial solid waste and hazardous waste (see Chapter 10).

In 1978 the paper and allied products industry ranked eighth (1.6 billion dollars) and eleventh (0.1 billion dollars) among manufacturing sectors in earnings in regions 4 and 6, respectively. This represented 26 percent of national earnings in the industry. The industry has typically located along the coasts and the major rivers of the forested eastern two-thirds of the study area from eastern Texas and Oklahoma to the Atlantic.

Earnings in the industry are projected to grow more rapidly in Region 6 (241 percent) than in Region 4 (170 percent) over the period 1978 to 2010, but the absolute increase is projected to be almost twice as large in Region 4. Both absolute growth in earnings and 2010 earnings are projected to be largest in Texas and Georgia, with smaller concentrations in North Carolina, Tennessee, Alabama, Arkansas, and Louisiana.

4.4.6 Metal and Nonmetal Mining

Metal mining (SIC 10) and nonmetal mining (SIC 14) includes the exploration for and mining of metallic ores and nonmetals, including primary preparation such as washing, crushing, grinding, and beneficiation of mined products. Such mining is a small and localized sector within the Sunbelt and is not included as one of the major industrial driving forces. However, because it is so localized, and often environmentally disruptive, it is important in a few areas within the South. Environmental problems include extensive surface disruption, disposal of spoils, production of airborne particulates and waterborne suspended solids and dissolved solids.

New Mexico dominates, and is projected to continue to dominate, the Sunbelt's production of minerals, with significant output of copper and uranium plus some silver and gold (Oxford Regional Economic Atlas, 1975). In 1978, the state produced 82 percent of Sunbelt and 12 percent of U.S. earnings in metal mining. Industry earnings in New Mexico are projected to increase by 275 percent between 1978 and 2010 and to represent 21 percent of the increase in U.S. earnings in the industry.

Florida, Georgia, and Texas dominate the pattern for mining nonmetallic minerals. The South Texas Coast is the site of major

Frasch process sulfur mines and Florida has large phosphate mining centers (Oxford Regional Economic Atlas, 1975). Earnings in these three states in this industry are projected to grow by 90 to 160 percent over the period 1978 to 2010, representing about half of projected Sunbelt and 18 percent of projected U.S. earnings increases.

4.5 REGIONS OF CONCENTRATED INDUSTRIAL ACTIVITY

The columns of Table 4-5 can be used as one means to identify states with the potential to experience significant environmental impacts in the future from a wide range of manufacturing, mining, and agricultural industries. As mentioned before, however, this approach does have limitations. The lack of potential impacts from a variety of industries does not mean impacts from a few industries are not severe, and the fact that a state does not have a large share of the southern industry does not mean significant concentrations of the industry do not occur within the state.

Texas and Louisiana in Region 6 and Florida, Georgia, North Carolina, and Tennessee in Region 4 stand out as states predicted to have large concentrations of a wide variety of environmentally significant industries. The Texas/Louisiana center is projected to be characterized by concentrations of the core manufacturing sectors of metals, machinery, and transportation equipment; the pulp and paper industry; and the full range of petroleum and natural gas based industries from extraction, to refining, to manufacture into chemicals, plastics, and rubber. In addition, Texas--but not Louisiana--is projected to have concentrations of agriculture, food processing, nonmetal mining, and stone, clay, and glass manufacture. The North Carolina/Georgia/Tennessee center is projected to also be characterized by concentrations of the core manufacturing sectors; the pulp and paper industry; food processing; and stone, clay, and glass manufacture. It is differentiated from the Texas/Louisiana center by the presence of only the later chemical, plastic, and rubber manufacturing stages of the petroleum based group of industries and by the importance of the textile industry. Florida is projected to contain concentrations of the core manufacturing sectors; agriculture; food processing; nonmetal mining; and stone, clay, and glass manufacture. It is distinguished from the other two centers by the relative unimportance of the petroleum-based industries, textiles, and pulp and paper.

If the above analysis were based not on the projected size of the industry in 2010, but on the projected absolute change in earnings between 1978 and 2010, the results would be very similar. States projected to see the greatest increases in a wide variety of environmentally significant industrial activities include Texas/Louisiana in Region 6 and Tennessee/North Carolina/Georgia/Florida in Region 4. However, Kentucky would also be included in the

Tennessee/North Carolina/Georgia group; its growth would be characterized by increases in core manufacturing, petroleum refining, rubber manufacture, agriculture, and coal mining. Tennessee, which was already highly industrialized in 1978, would be less prominent because the change in, as opposed to size of, industries such as primary and fabricated metals and food processing would be smaller than in other states.

4.6 SUMMARY

The Sunbelt will see great industrial growth in all sectors over the next 30 years. Growth rates in almost all sectors are projected to be significantly above U.S. averages and absolute increases are projected to be above increases in most of the other regions of the country. As in the rest of the nation, services will become increasingly more important in the Sunbelt economy. In contrast to the nation as a whole, where manufacturing is projected to decrease in relative importance, manufacturing in the Sunbelt is projected to continue to grow rapidly and to maintain its share of the regional economy. Mining (i.e., coal mining in the eastern Sunbelt and oil and gas production in the west) will continue to be a very important part of the regional economy.

This industrial growth will bring important and much desired benefits to the South. Employment to population ratios, wage rates, and per capita incomes are all expected to increase to near national averages (see Chapter 3). Outmigration and population decline in many areas of the South are becoming trends of the past.

The magnitude of projected industrial growth also creates the potential for significant environmental change, however. Growth within a number of industrial sectors--selected on the basis of their size, projected growth, and production of undesirable wastes --present the greatest potential problems. These sectors include primary and fabricated metals; machinery and transportation equipment manufacture; the energy mineral-based industries including coal, petroleum, and gas extraction and processing into fuels, chemicals, plastics, and rubber; textiles; agricultural and forest production; food processing; and pulp and paper manufacture. States projected to include large concentrations or to experience major change in a wide variety of these industries include Louisiana and Texas in Region 6 and Tennessee, Kentucky, North Carolina, Georgia, and Florida in Region 4.

Certain of the industries identified in this chapter stand out as key driving forces projected to have the potential to create significant environmental changes in the Sunbelt. The current status of, projected trends in, and environmental problems associated with some of these industries are examined in more detail in Volume II. The two most important of these industries are energy production (Chapter 6) and chemical manufacture (Chapter 7). The South has traditionally been a major supplier of energy to the nation. It has a large share of national reserves of fuel minerals; with the growth of both the regional and the national economy, the extraction of these fuels and their conversion to usable gases, liquids, solids, and electricity will be a major source of air and water pollution, solid and hazardous wastes, and land surface disruption. The chemical industry will continue to be one of the most important and most rapidly growing Sunbelt industries. Although in recent years it has been one of the largest stationary sources of air and water pollutants in the South, the large volume of hazardous wastes produced by the industry and their safe disposal will continue to be one of the most serious environmental problems facing the Sunbelt.

Other key driving forces include agricultural and forest production (Chapter 9), the textile industry (Chapter 8), and the pulp and paper industry (Chapter 10). Although earnings in agricultural and forest production are not projected to grow as rapidly as in other sectors, the number of acres of land affected may be large. These activities are already the source of tremendous quantities of waterborne suspended particulates, nutrients, BOD, coliforms, and pesticides. The textile industry is one of the largest manufacturing industries in the South and is projected to double over the next 30 years. Although it produces water pollutants such as BOD, solids, and waste heat, the major concern is the rapidly changing character of hazardous process chemicals and heavy metals used by the industry that may be disposed of in wastewater streams or as hazardous wastes. The concentration of both current production and anticipated growth in this industry in the three state North Carolina/South Carolina/Georgia area intensifies the concerns associated with textile manufacturing. Finally, the pulp and paper industry will continue to be an important and growing manufacturing industry in the Sunbelt because of the extent and productivity of southern forests. The industry is a major source in the Sunbelt of a wide variety of wastes, including waterborne BOD and suspended solids and odoriferous compounds.

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TABLE 4-A1: REGIONS 4 AND 6 DURABLE MANUFACTURING EARNINGS BY INDUSTRY BY STATE--1978 and 2010[a]

	AL	FL	GA	KY	MS	NC	SC	TN	AR	LA	NM	OK	TX	South	U.S.
Lumber Products	243 705 462	179 528 349	237 649 412	90 207 117	207 605 398	274 457 183	125 313 188	154 284 130	184 427 243	145 321 176	25 76 51	40 130 90	313 1,053 740	2,216 5,754 3,538	7,375 18,047 10,672
Furniture & Fixtures	53 191 138	76 245 169	65 158 93	47 94 47	116 354 238	561 1,628 1,067	35 101 66	170 444 274	84 181 97	8 14 6	2 4 2	17 63 46	132 451 319	1,364 3,926 2,562	3,819 9,457 5,638
Stone, Clay & Glass Products	106 352 246	211 836 625	167 501 334	99 326 227	72 260 188	167 612 445	114 359 245	198 771 573	49 149 100	96 321 225	25 105 80	112 404 292	434 1,697 1,263	1,850 6,693 4,843	7,922 21,563 13,641
Primary Metals	672 1,738 1,066	47 219 172	177 725 548	274 868 594	30 145 115	83 280 197	67 402 335	241 718 477	92 389 297	107 830 723	15 178 163	64 216 152	603 2,623 2,020	2,471 9,331 6,860	18,623 47,401 28,738
Fabricated metals	241 756 515	315 1,182 867	188 552 364	223 721 498	98 450 352	248 1,171 923	127 618 491	323 1,143 820	125 408 283	187 725 538	13 50 37	229 988 759	959 5,176 4,217	3,276 13,939 10,663	18,787 51,159 32,372
Machinery (including electric)	290 1,511 1,221	815 3,203 2,388	344 1,171 827	871 2,962 2,091	315 2,320 2,005	878 3,218 2,340	435 1,196 761	703 3,234 2,531	322 1,202 880	232 1,717 1,485	52 237 185	485 2,400 1,915	2,455 14,133 11,678	8,197 39,502 31,305	50,889 145,376 94,487
Transportation Equipment (including motor vehicles)	230 b -	517 1,374 857	484 1,268 784	263 1,190 927	314 870 556	124 663 539	40 85 45	271 1,269 998	70 254 184	277 1,109 832	31 117 86	151 691 540	1,643 2,557 914	3,693 12,184 8,491	30,846 75,446 44,600
Instruments	33 212 179	94 632 538	31 104 73	28 218 190	13 38 25	96 393 297	45 210 165	54 268 214	54 132 78	11 62 51	2 27 25	18 64 46	164 815 651	643 3,175 2,532	7,137 19,904 12,767
Miscellaneous Manufacturing	30 78 48	54 126 72	49 117 68	31 79 48	31 117 86	35 108 73	30 66 36	84 289 205	28 55 27	10 28 18	15 44 29	16 55 39	93 390 297	504 1,552 1,048	3,688 7,547 3,859

Source: Calculated from U.S., Department of Commerce, Bureau of Economic Analysis (BEA). 1980. Regional Economic Projections. Washington, D.C.: BEA.

[a] First row (earnings in the industry in 1978); second row (earnings in the industry in 2010); third row (absolute change 1978 to 2010).

[b] Data witheld.

TABLE 4-A2: REGIONS 4 AND 6 NONDURABLE MANUFACTURING EARNINGS BY INDUSTRY BY STATE--1978 and 2010[a]

(millions of 1972 dollars)

	AL	FL	GA	KY	MS	NC	SC	TN	AR	LA	NM	OK	TX	South	U.S.
Food and Kindred Products	213 410 197	467 1,075 608	495 1,075 580	237 516 279	150 325 175	338 757 419	112 249 137	377 750 373	230 681 451	248 531 383	38 97 59	150 325 175	891 2,164 1,273	3,944 8,953 5,009	17,467 32,129 14,662
Tobacco Products	b 8 b	17 7 -10	b 2 b	147 213 66	b b b	322 474 152	4 5 1	15 42 27	b b -	b b -	b b -	b b -	1 1 0	504 766 262	792 1,230 438
Textile Mill Products	316 600 284	27 106 79	912 1,967 1,055	46 135 89	39 104 65	1,759 3,506 1,747	1,101 2,233 1,132	191 311 120	31 65 34	b 85 -	6 17 11	10 28 18	47 83 36	4,485 9,241 4,756	6,608 12,778 6,170
Apparel and Other Fabricated	262 671 409	180 419 239	381 892 511	148 314 166	198 522 324	438 1,186 748	242 578 336	356 852 496	73 144 71	54 194 140	15 44 29	62 163 101	413 1,378 965	3,933 7,359 3,426	7,933 15,831 7,898
Paper and Allied Products	274 708 434	203 417 214	339 921 582	77 280 203	90 205 115	252 667 415	174 510 336	194 617 423	158 573 415	215 598 383	1 2 1	26 114 88	249 922 673	2,250 6,535 4,285	8,504 19,856 11,352
Printing and Publishing	84 258 174	313 1,174 861	180 560 380	126 375 249	37 171 134	152 524 372	54 173 119	193 571 378	64 202 138	73 238 165	21 88 67	82 267 185	477 1,711 1,234	1,855 6,312 4,457	11,724 28,916 17,192
Chemicals and Allied Products	192 630 438	301 812 511	181 656 475	216 487 271	75 348 273	411 1,614 1,203	387 1,239 852	747 1,953 1,206	92 370 278	511 2,791 2,280	6 16 10	39 184 145	1,211 4,803 3,592	4,368 15,907 11,539	14,886 43,562 28,676
Petroleum Refining	b 46 -	20 61 41	b 53 -	61 246 185	26 116 90	4 9 5	4 11 7	10 30 20	22 47 25	213 649 436	18 73 55	129 274 145	813 1,974 1,161	1,319 3,589 2,270	3,680 8,792 5,112
Rubber and Miscellaneous Plastics	168 539 371	111 467 356	123 403 280	101 581 480	65 362 297	220 947 727	147 912 765	256 1,057 801	79 266 187	b 58 -	1 4 3	111 596 485	279 1,312 1,033	1,661 7,504 5,843	7,605 22,760 15,155
Leather and Leather Products	5 1 -4	19 15 -4	14 21 7	24 33 9	11 15 4	27 59 32	1 3 2	130 160 30	43 55 12	1 2 1	3 10 7	3 12 9	45 74 29	326 458 132	1,558 1,839 281

Source: Calculated from U.S., Department of Commerce, Bureau of Economic Analysis (BEA), 1980. Regional Economic Projections. Washington, D.C.: BEA.

[a] First row (earnings in the industry in 1978); second row, (earnings in the industry in 2010); third row, (absolute change 1978 to 2010).

[b] Data witheld.

TABLE 4-A3: REGIONS 4 AND 6 AGRICULTURE AND MINING EARNINGS BY INDUSTRY BY STATE--1978-2010[a] (millions of 1972 dollars)

	AL	FL	GA	KY	MS	NC	SC	TN	AR	LA	NM	OK	TX	South	U.S.
Agricultural Production	411	912	521	437	416	1,069	213	282	665	242	160	253	880	6,460	22,125
	510	1,629	875	885	503	1,572	253	296	828	460	288	510	1,524	10,131	35,205
	99	717	354	448	87	503	40	14	163	218	128	257	644	3,671	13,080
Coal Mining	177	b	1	787	b	b	b	73	6	b	b	26	8	1,079	2,804
	981	b	3	3,782	1	1	1	416	17	b	309	58	100	5,668	19,471
	804	b	2	2,995	b	b	b	343	11	b	b	32	92	4,589	16,667
Crude Petroleum and Natural Gas	6	b	1	42	103	<1	<1	5	40	1,041	b	813	2,787	4,834	6,687
	34	51	14	36	180	1	19	3	58	1,334	207	1,051	3,455	6,440	11,332
	b	b	13	-6	77	<1	19	-2	18	293	b	238	668	1,606	4,644
Metal Mining	b	b	1	b	b	b	b	16	5	b	148	b	11	181	1,286
	1	9	1	<1	b	<1	b	24	16	2	555	<1	34	641	3,220
	b	b	0	b	b	b	b	8	11	b	407	b	23	460	1,934
Nonmetal Mining (excluding fuels)	22	92	73	27	11	46	16	33	14	b	40	15	82	470	1,388
	44	179	151	61	29	86	38	64	27	93	77	38	214	1,100	3,035
	22	87	78	34	18	40	22	31	13	b	33	23	132	630	1,648

Source: Calculated from U.S., Department of Commerce, Bureau of Economic Analysis (BEA). 1980. Regional Economic Projections. Washington, D.C.: BEA.

[a] First row (earnings in the industry in 1978); second row (earnings in the industry in 2010); third row (absolute change 1978 to 2010).

[b] Data witheld.

CHAPTER 5

ENVIRONMENTAL VALUES AND ATTITUDES

HIGHLIGHTS

Status and Trends

1. Support for environmental goals comes from a broad base in society--sixty percent of Americans surveyed in 1980 expressed sympathy for the environmental movement. However, the lowest levels of support come from the states in Region 4--Kentucky, Tennessee, Mississippi, and Alabama.

2. While public opinon data on trade-offs between the environment and other issues are ambiguous, there is no strong evidence that the public wants to sacrifice environmental protection in order to achieve economic goals. For example, the percentage of respondents who believe that both economic and environmental goals can be met has grown from 18 percent in 1978 to 75 percent in 1981.

3. Those ranking "reducing air and water pollution" as one of the nation's three most pressing problems dropped from 53 percent in 1970 to 24 percent in 1980. This change represented the biggest shift among all the public issues considered. In addition, those who believe the federal government is not spending enough on the environment dropped by 14 percent between 1970 and 1980, from 62 percent to 48 percent.

4. Political trends and public opinion data suggest that costs will be an increasingly important factor in assessing environmental regulation strategies. Over the past three years, for example, the position of "holding down costs rather than requiring stricter controls" gained 14 percent in support, up from 20 percent in 1977 to 34 percent in 1980.

5. People expect environmental problems to continue well into the future. Over two-thirds of those surveyed in 1978 believe that air and water pollution will still be serious problems in the year 2000. Only the West viewed air and water pollution as more of a problem than did the South.

- Geographic Areas

6. The South Atlantic region believes that significant improvements have been made since 1975 in both air and water quality. In the East Southcentral states of Kentucky, Tennessee, Mississippi, and Alabama, respondents perceived an improvement in air quality and some deterioration in water quality, while respondents in the West Southcentral region (Texas, Louisiana, Arkansas, and Oklahoma) perceived water quality as much worse than in 1975.

7. The South, more than other regions of the U.S., appears to favor development of natural resources for residential and agricultural use even if it means destruction of wetlands, wilderness, or wildlife.

8. According to a survey, Kentucky, Tennessee, Mississippi, and Alabama show less support for the environmental movement than does the rest of the nation.

- Key Problems and Issues

9. Regarding the question of the need to cut federal spending and regulation, public opinion data from a recent survey commissioned by Union Carbide Company found strong public support for government regulations which protect the public. By sizeable majorities, people said the government should provide even stricter regulations to protect the work place, the safety of products, and the environment.

10. The degree of public concern for issues such as toxic substances, facility siting, drinking water, and air pollution varies considerably. Among these, the strongest support is shown for maintaining air and water quality.

11. Concern is increasing for pollution from chemical wastes. Forty-six percent of the people are worried a great deal about the presence of toxic chemicals such as pesticides or PCB's in the environment and 62 percent are worried a great deal about the disposal of industrial wastes.

CHAPTER 5

ENVIRONMENTAL VALUES AND ATTITUDES

5.1 INTRODUCTION

Environmental policy occurs within the broad context of social values and attitudes about the importance of environmental quality, concerns about economic trade-offs, and the conflicting pressures of national energy policy. Thus, an important concern in understanding and anticipating the changes occurring throughout the Sunbelt is how residents in this area view a range of issues related to their environment and whether or not these views differ from those of the rest of the nation. The 1970's have been called the "decade of the environment," reflecting broad public and political support for protecting and enhancing our air, water, and land resources and resulting in major pieces of environmental legislation. Considering the progress made toward meeting environmental goals during these years and the current economic concerns of the nation, an emerging question affecting virtually every issue discussed in this report is whether or not such broad support for environmental protection will continue, especially in the Sunbelt where growth and development is occurring at a relatively rapid rate.

This chapter addresses this question by reviewing indicators of social values and attitudes in order to develop a general picture about support for the environment and to identify indicators of potential change in the direction of support. Although a variety of indicators is discussed, emphasis is placed on recent public opinion data; information specific to the Sunbelt has been highlighted if available. The next section (5.2) presents current trends in public opinions about the environment. Three specific topics are addressed: general attitudes about the environment; trade-offs between the environment, energy, and economics; and factors causing changes in environmental support. Section 5.3 provides a brief discussion of other indicators of social values and attitudes. A final section (5.4) summarizes these various data with an assessment of the current status of public support for the environment.

5.2 PUBLIC ATTITUDES ABOUT THE ENVIRONMENT

5.2.1 Public Opinion Research

Public opinion polls are useful in providing a representative picture of the nation's attitudes. This is particularly important since attitudes can be identified for groups of people who do not ordinarily participate directly in the policymaking process. When conducted repeatedly over time and evaluated along with other indicators, public opinion research can identify trends or changes in attitudes and characterize the public's understanding of and concern about public policy issues.

Opinion polls do have some limitations. Bias may be introduced if questionnaires are not designed and tested carefully; care must be taken to assess respondents' level of information about current issues; and the occurrence of key events can alter the timeliness of the data. Nonetheless, people do hold opinions which reflect their values and often indicate their behavior. Thus, current opinion and factors causing changes of opinion are important policy considerations for public officials.

5.2.2 General Attitudes About the Environment

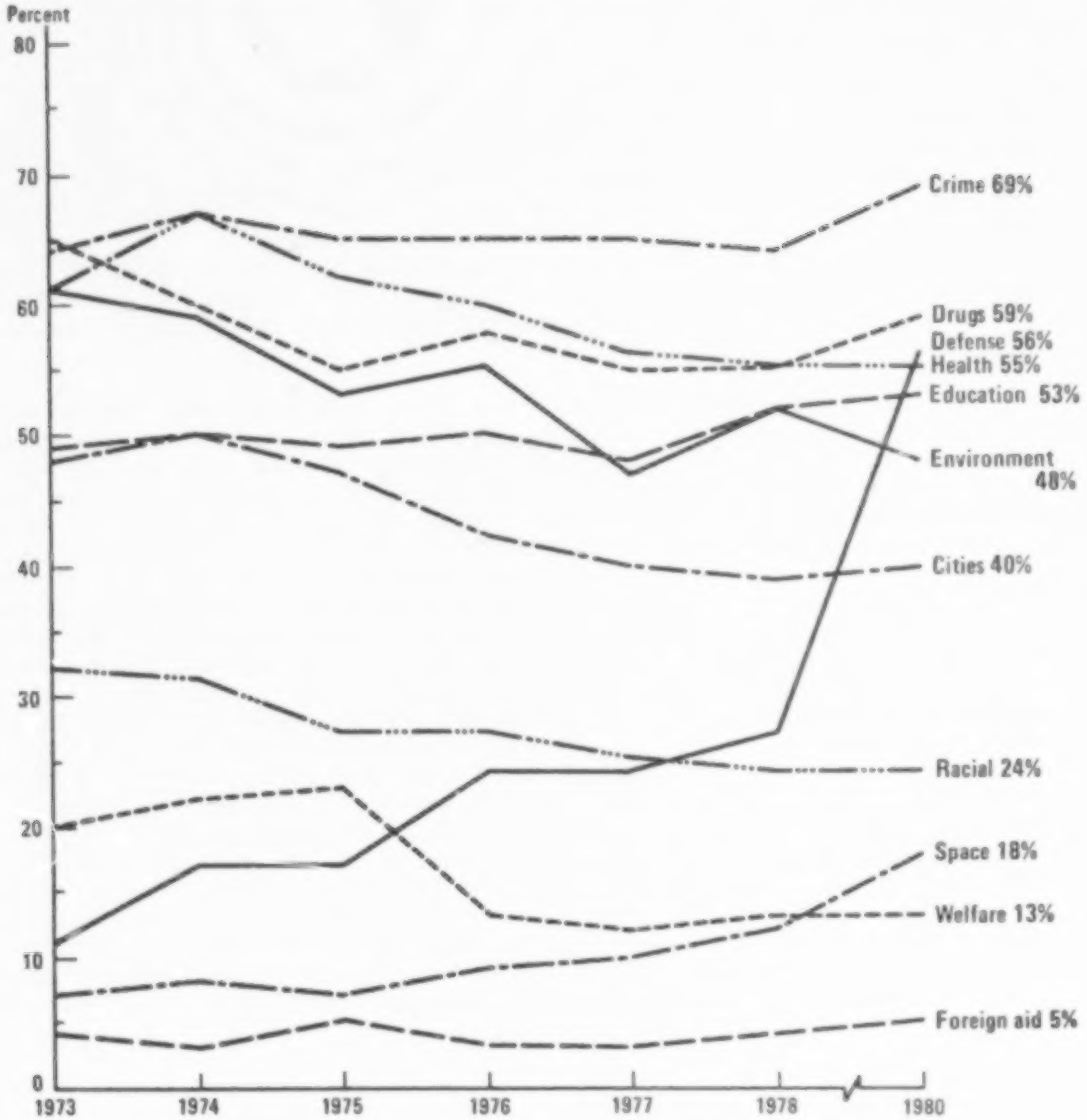
Although the issues have changed through the years, Americans have traditionally been concerned about the nation's environment. For example, by the middle of this century, increasing awareness of public health benefits from maintaining clean air and water supplies led to federal legislation establishing nationwide standards for air and water quality, creating grants for construction of sewage treatment plants, and providing mechanisms for public hearings on related problems (Council of State Governments, 1980). At the same time that air and water quality standards were being strengthened, evidence began to accumulate that pesticides and fertilizers were entering the ecological chain through farming practices. Rachel Carson's Silent Spring, warning of the implications of overuse of pesticides such as DDT as well as other commercial insecticides, fertilizers, fungicides, and herbicides, was particularily instrumental in alerting the public to these new dangers (U.S., EPA, 1980).

Other events or episodes which played a role in raising the public's awareness of environmental issues include the Sierra Club's battle over dams in the Grand Canyon in 1966; the oil well blowout in 1969 that spoiled beaches and marine life at Santa Barbara; the efforts of environmental groups to halt construction of the Alaska Oil Pipeline; the decision to halt flights of the SST in the United States in 1977; and the impacts of the Love Canal hazardous waste disposal site. The Sunbelt has experienced its share of controversy over such issues as the Miami jetport proposed for the Everglades, the Cross-Florida barge canal, Oklahoma's Black Fox nuclear power plant, and the Tennessee-Tombigbee Waterway.

Widespread agreement now exists that over the past 30 years, particularly during the late 1960's and early 1970's, the environment moved from a position of minor concern as a national priority to one of primary importance. In 1970, shortly after the celebration of Earth Day, a Gallup Poll asked a representative sample of the American public to choose, out of a list of ten problems, the three which should get the most attention in the next five years. Fifty-three percent chose "reducing pollution of air and water" placing it second only to "reducing the amount of crime" (U.S., CEQ, 1980).

Strong environmental laws have been enacted over the ensuing ten years, and substantial progress has been made toward meeting established goals. In addition, issues such as the energy crisis, unemployment, inflation, and the Middle East conflicts have become increasingly important. Thus, it is not surprising that the percentage of people who ranked "reducing pollution of air and water" as one of the top three national problems has declined from 53 percent in 1970 to 24 percent in 1980. A similar indication of the public's realignment of national priorities is reflected in judgments of the appropriate level of spending for major policy areas. Over the past eight years support for increasing spending on the environment has dropped by about 15 percent (see Figure 5-1). In 1973, 63 percent of those surveyed thought we were spending too little on the environment. By 1980, only about half (48 percent) said that we are spending "too little" on the environment. However, only 15 percent believed we were spending "too much" while 31 percent said the amount was "about right." The South's opinion regarding the level of spending for the environment seems to be similar to the national trend. Even though support started at a lower level of 56 percent in 1973, southern support for spending caught up with the national level in the 1974 survey and has remained with the trend thereafter (NORC, in U.S., CEQ, 1980).

The public clearly expects environmental issues to be an ongoing problem. When asked to judge the "seriousness of different problems in the year 2000," most respondents in a national survey (Roper, 1978) judged severe air and water pollution and water shortages as serious problems in the year 2000. Over 70 percent thought air and water pollution would still be severe problems by the year 2000, while 56 percent thought that shortages of water supplies would be severe. Public opinion in the South about this question was similar to that found nationwide. Only the West viewed air and water pollution as more of a problem than did southerners.



1. National Opinion Research Center, University of Chicago, General Social Survey, personal interview survey, with an average sample size of approximately 1,500. The 1980 interviews were conducted in February-April with N=1,468.

"We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one I'd like you to tell me whether you think we're spending too much money on it, too little money, or about the right amount . . . ."

Figure 5-1: Percent Saying That We're Spending "Too Little" on Eleven Problems, 1973-80

Source: U.S., CEQ, 1980, p. 10.

When people were asked about changes in their local air and water quality, however, clear regional differences emerged (Mitchell, R. C., 1981). Although respondents from the South Atlantic region rated their local air and water quality as the lowest in the nation, they believed that significant improvements had been made since 1975 in both air (+8 percent) and water quality (+10 percent) in their area (See Figure 5-2).[1] In the East Southcentral states, respondents perceived considerable improvement in air quality (+15 percent), but deterioration in water quality (-2 percent). In the West Southcentral states, some pessimism is evident about water quality (-6 percent) and air quality (-2 percent).

In general, the data show that support for the environment comes from a broad base in society (see Figure 5-3) rather than from any special geographic or demographic subgroup. Almost two-thirds (six out of ten) of the public surveyed expressed sympathy for the environmental movement. Only three groups do not have a majority sympathetic to the movement--blacks, those without a high school education, and residents of the East Southcentral states of Kentucky, Tennessee, and Mississippi (Mitchell, R. C. 1980a). These same southern states also had a relatively large number of respondents (39 percent) who replied "not at all" when asked if the term "environmentalist" applied to their interests (see Table 5-1) as did the West Southcentral states (30 percent) of Texas, Oklahoma, Louisiana, and Arkansas.

5.2.3 The Environment Versus Other Public Priorities

As economic conditions have deteriorated, questions about trade-offs such as the cost of cleaning up the environment versus the acceptability of some environmental deterioration have become more important. Considerable attention is now focused on the trade-offs between specific environmental regulations and other public priorities such as economic growth, development of natural resources, and adequate supplies of energy. This is particularly true in the South where there is less development in comparison with other regions (except for the Rocky Mountains) and a lagging income in comparison to the U.S. average (see chapters 3 and 4). As discussed below, opinions about this issue are mixed both for the nation and the South.

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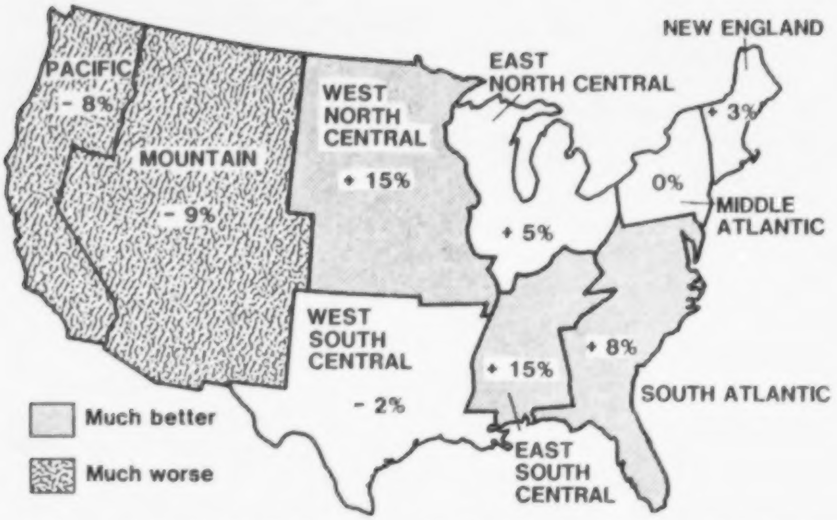
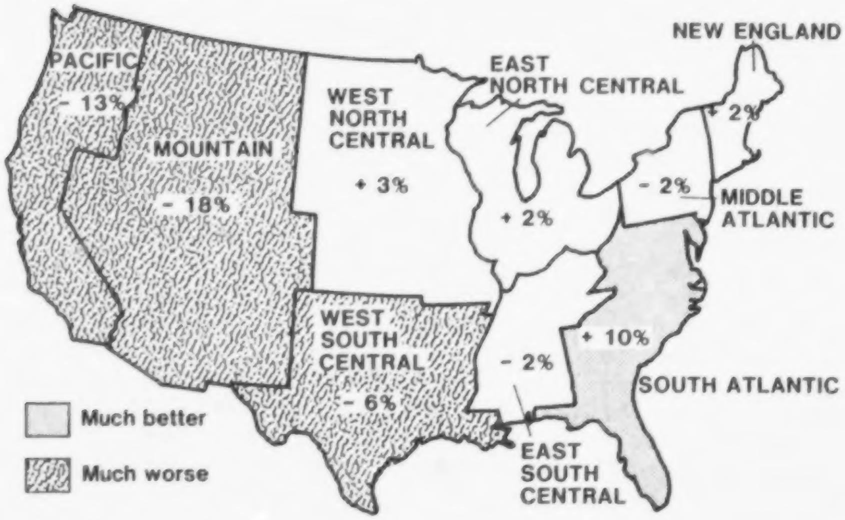
[1] To calculate the percent change in air and water quality, the percentage of those rating present air or water quality at two or more steps lower (on a self anchoring ladder) than five years ago was subtracted from the percentage of respondents rating present air or water quality as two or more steps higher than five years ago. Those who showed no change or less than two steps either direction were considered "no change".



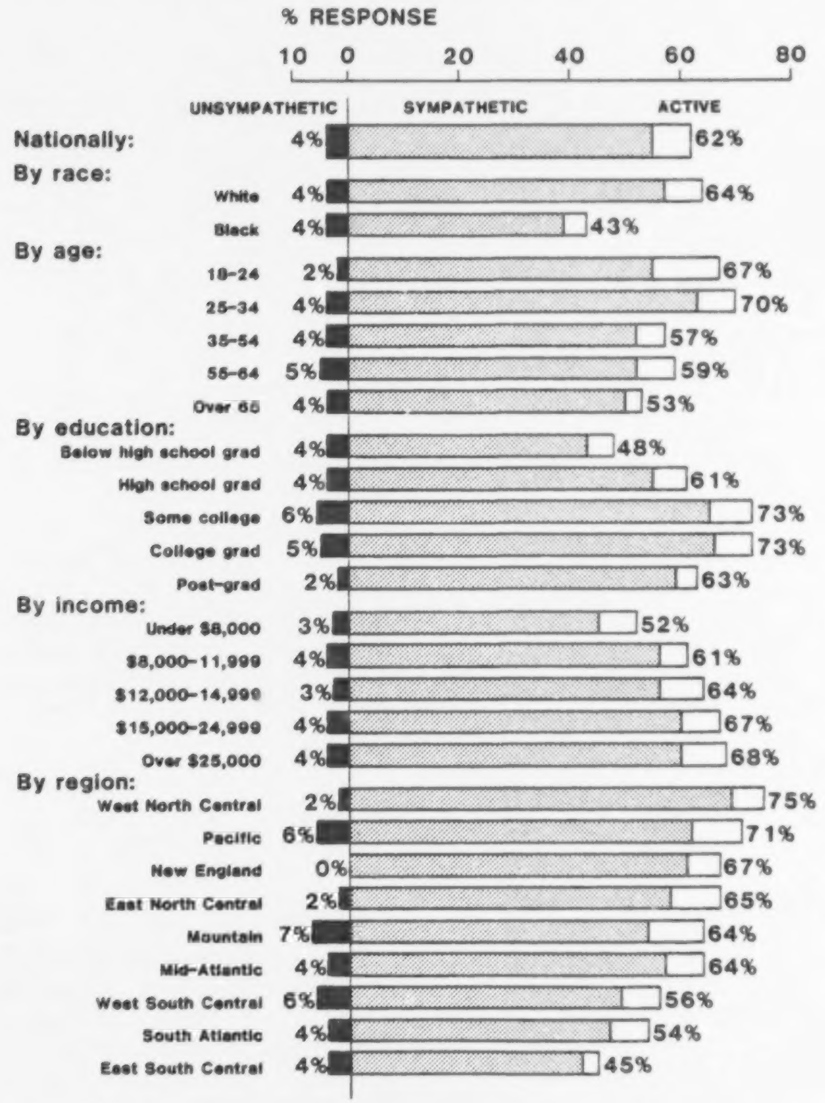
Balance of Those Who Believe Local Air Quality Has Improved Significantly In the Last Five Years Minus Those Who Believe It Has Significantly Worsened



Balance of Those Who Believe Local Water Quality Has Improved Significantly In the Last Five Years Minus Those Who Believe It Has Significantly Worsened

Figure 5-2: Rating Improvements in Local Air and Water Quality Over the Past Five Years

Source: Mitchell, R. C., 1981, p. 12.



1. RFF survey, Q. 54. In recent years, the environmental movement has been very active. Do you think of yourself as: an active participant in the environmental movement, sympathetic towards the movement but not active, neutral, or unsympathetic towards the environmental movement?

The categories not shown on this figure and the national percentages are: neutral, 31 percent; not sure, 3 percent.

Figure 5-3: Views of the Environmental Movement[1]

Source: U.S., CEQ, 1980, pp. 44-45

TABLE 5-1: SELF-IDENTIFICATION AS AN "ENVIRONMENTALIST"[a]

Region[b]	Definitely	Somewhat	Not at all	Not Sure	(N)
South Atlantic	19%	51%	25%	5%	(523)
East Southcentral	14	44	39	4	(176)
West Southcentral	23	46	30	2	(275)
Mountain, Pacific	16	60	22	2	(519)
East and West Northcentral	16	65	16	3	(784)
New England and Mid Atlantic	19	50	29	2	(732)
Total U.S.	18	55	24	3	(3,009)

N = sample size

Source: U.S., CEQ, 1980.

[a] Question: "Now I am going to read you some phrases that describe different kinds of interests people have. As I read each one, would you please tell me whether it definitely applies to you, or only somewhat or not at all?...(b) an "environmentalist".

[b] U.S. Bureau of Census Regions.

A. Economic Costs of Protection

One indicator of public reaction to environmental versus economic issues is whether pollution controls are perceived to be worth the costs entailed. Between 1977 and 1980, the percentage of respondents who said that "protecting the environment is so important that requirements and standards cannot be too high, and continuing improvements must be made regardless of cost" declined from 55 to 42 percent (see Figure 5-4). A recent poll (CBS/NY Times, 1981) found that 40 percent of the respondents in the South[1] supported this position compared to 48 percent in the East and West and 46 percent in the Midwest.

Those believing that pollution control "already costs more than it is worth" also declined 6 percent between 1977 (19 percent) and 1980 (13 percent). Thus, a middle position of "holding

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[1] The CBS/New York Times Poll defines "South" as Virginia and the 13-state study region minus New Mexico.

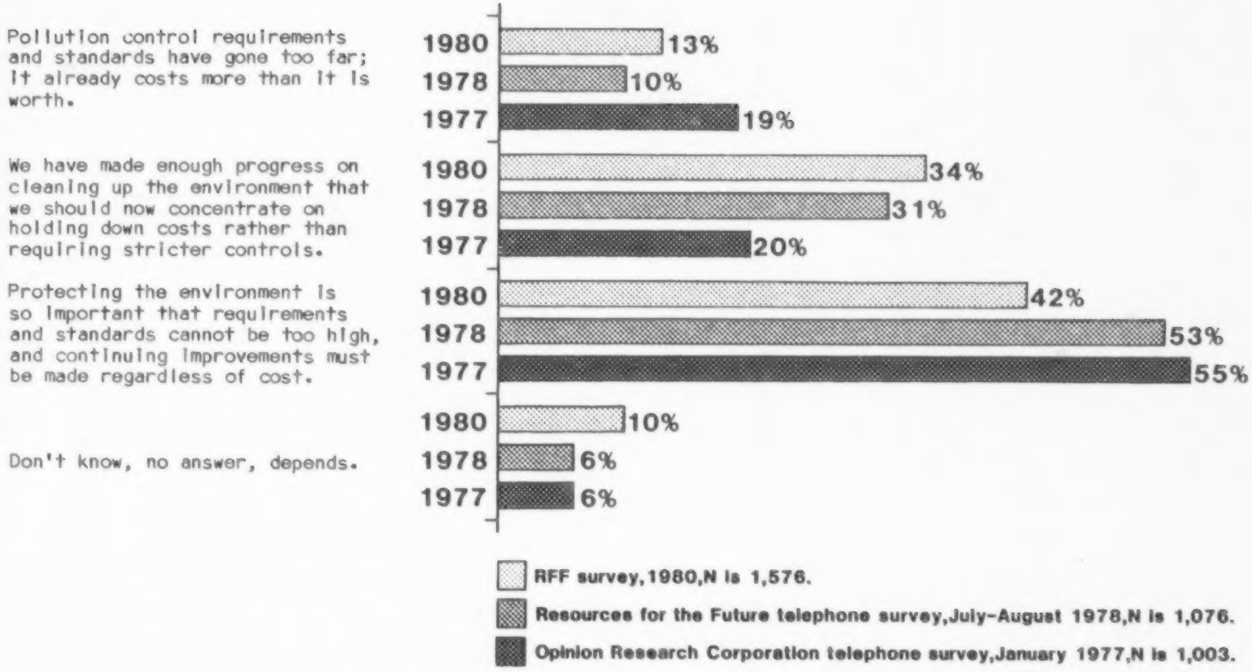

Figure 5-4: Views About Pollution Control, 1977-1980

Source: U.S., CEQ, 1980, p. 13.

Question: I am going to read you three points of view regarding pollution control. Please tell me which one best represents your opinion.

down costs rather than requiring stricter controls" gained support, from 20 percent in 1977 to 34 percent in 1980. The East Southcentral region consisting of Kentucky, Tennessee, Mississippi, and Alabama was the only one expressing more concern for holding down costs (49 percent) than for continuing environmental improvements (34 percent) in 1980 (see Table 5-2). Otherwise residents in the Sunbelt seem to have much the same priorities as the rest of the nation.

Some reluctance to weaken environmental control programs in the interest of the economy continues to show up in the polls. In January 1979, 62 percent of the respondents in a Harris Poll favored "a major cutback in federal government spending"; yet 57 percent of the respondents opposed such a cutback if it meant "cutting back spending for environmental protection." In a

TABLE 5-2: VIEWS OF SUNBELT RESIDENTS ABOUT POLLUTION CONTROL IN 1980

Statement	South Atlantic	East South-central	West South-central
Protecting the environment is so important that requirements cannot be too high, and continuing improvements must be made regardless of costs.	42%	34%	47%
We have made enough progress on cleaning up the environment that we should now concentrate on holding down costs rather than requiring stricter controls.	32	49	33
Pollution control requirements and standards have gone too far; it already costs more than it is worth.	15	10	11
Don't know, no answer, depends	12	7	9

Source: U.S., CEQ, 1980.

February 1980 Newsweek/Gallup Poll, 87 percent of the respondents wanted to maintain or increase government spending for water pollution control programs (U.S., CEQ, 1980). And in June 1981, 58 percent of the respondents agreed that "government regulations and requirements to protect the environment are worth the extra costs added to the products and services the average person buys" while 53 percent opposed "reducing auto-exhaust regulations that add to the price of new cars" (Newsweek/Gallup). These responses suggest that the public is concerned about the costs of protecting the environment, but they are not willing to give up gains already made. This highlights the need for questions which focus more directly on the relative importance and effectiveness of different environmental programs.

B. Economic Growth

When given the choice of relaxing environmental standards to achieve economic growth or accepting a slower rate of growth to protect the environment, respondents continue to choose the environment by a margin of 27 percent to 19 percent (see Table 5-3).

TABLE 5-3: VIEWS ABOUT ECONOMIC GROWTH AND ENVIRONMENTAL PROTECTION[a]

Statement	1978[b]	1980[c]
We must relax environmental standards in order to achieve economic growth.	20%	19%
We can achieve our current goals of environmental protection and economic growth at the same time.	18	41
We must accept a slower rate of economic growth in order to protect the environment.	58	27
Depends (volunteered).	4	4
No opinion, don't know.		9
N=	1,002	1,576

Source: U.S., CEQ, 1980.

[a] Question: I am going to read you three statements about environmental protection and economic growth. Please listen carefully and tell me which statement you agree with the most.

[b] ORC Public Opinion Index, Vol. 36, Nos. 17 and 18, September 1978. Interviewing took place August 24-30, 1978.

[c] RFF survey, 1980.

However, the margin for this choice has declined since 1978, when 58 percent favored the environment. A larger percentage (41 percent) of respondents in 1980 believed that both goals could be met than in 1978 (18 percent). In June 1981 (Newsweek/ Gallup) 75 percent of the respondents thought "it is possible to maintain strong economic growth in the U.S. and still maintain high environmental standards."

When given the specific choice between a manufacturing plant providing jobs or a marsh that supports an endangered bird species (see Table 5-4), a majority in all regions rejected the plant and its jobs (Kellert, 1979). The South, however, had the smallest percentage (51.0 percent) of people in favor of protecting the marsh and endangered birds (Kellert, 1979). The South also had the smallest percentage (51 percent) of people in favor of "keeping present air pollution laws even if some factories must close" compared to 70 percent support in the West, 67 percent). the East and 59 percent in the Midwest (CBS/NY Times, 1981).

C. Development of Natural Resources

When the public was given a choice between development of natural resources and wilderness preservation, the choice was for

TABLE 5-4: PUBLIC ATTITUDES TOWARD BUILDING A PLANT ON A MARSH WHICH SUPPORTS A RARE BIRD SPECIES, IN PERCENTAGES[a]

Region	Agree To Build	Disagree Do Not Build
South	42	51
Northeast	40	55
Northcentral	35	61
Rocky Mountains	38	59
Pacific	38	56

Source: Kellert, 1979.

[a] The question was: "A large coastal city has an unemployment problem. A major manufacturer wants to build a new plant on a marsh it owns which could employ 1,000 people, but conservationists claim this will destroy land needed by a rare bird. Do you agree that this plant should be built even if it endangers the bird species?"

preservation (see Table 5-5); between wetlands and housing development, the choice was for wetlands; and between paying higher lumber prices or sacrificing some wildlife, the choice was for paying higher prices.

The South emerged from Kellert's study as slightly more "pro-development" than other parts of the United States. For example, a majority (52 percent) of those surveyed in the South favored natural resource development even if it meant loss of wilderness and wildlife, while a majority in every other region of the U.S. supported the preservation of wilderness areas and wildlife (see Table 5-6).

D. Energy Issues

No area has produced more confusing polling results than that of energy. The combination of misinformation, disbelief, and

TABLE 5-5: PUBLIC ATTITUDES TOWARD HABITAT PROTECTION FOR WILDLIFE

Statement	% Agree	% Disagree
Natural resources must be developed even if the loss of wilderness results in much smaller wildlife population.	44	51
I approve of building on marshes that ducks and other nonendangered wildlife use if the marshes are needed for housing development.	39	57
Cutting trees for lumber and paper should be done in ways that help wildlife even if this results in higher lumber prices.	76	20
Cattle and sheep grazing should be limited on publicly owned lands if it destroys plants needed by wildlife, even though this may result in higher meat costs.	60	34

N = 2,759

Source: Kellert, 1979.

TABLE 5-6: PUBLIC ATTITUDES TOWARD NATURAL RESOURCE DEVELOPMENT BY REGION

Statement: Natural resources must be developed even if the loss of wilderness results in much smaller wildlife populations.

Region	% Agree	% Disagree
South	52	44
Northeast	45	49
Northcentral	41	53
Rocky Mountains	39	57
Pacific	38	57

N = 2,759

Source: Kellert, 1979.

uncertainty which characterizes the attitudes of many Americans toward the energy situation makes it difficult to find a consensus in public responses to questions on energy. For example, in the summer of 1979, over one-half of those surveyed (CBS/NY Times, 1981) still believed that the oil shortage was not real and over one-third (38 percent) believed that we were completely self-sufficient for energy needs (Richman, 1979).

Perhaps some of the skepticism regarding the energy shortage rests in the public's confidence in "American know-how" to produce alternative energy sources in the short-run. In the spring of 1979, 86 percent said they were optimistic (evenly split between somewhat or "very" optimistic) about "the ability of this country to solve the energy problem by technological discoveries and development." Just a week later, respondents in another Harris survey said that: (1) coal would become the chief energy source for the U.S. in the early 1980's; (2) nuclear and solar power would replace coal in the late 1980's; and (3) solar power would emerge as the primary source of U.S. energy in the year 2000 (Richman, 1979).

In 1980, solar energy was chosen by two out of three respondents (61 percent) as one of the top two or three energy sources preferred for the year 2000. However, the South showed less enthusiasm for installing solar energy systems in their homes than did other regions (U.S., CEQ, 1980), a finding that stands in contrast to the natural suitability of some Sunbelt areas for solar energy use.

In general, Americans have not seemed to favor protecting the environment if it means living without adequate energy supplies. During a seven-year period, from 1973 to 1979, in only one year (1976) did a plurality choose the environment over adequate energy supplies (U.S., CEQ, 1980). In 1979, a standoff emerged with 43 percent in favor of protecting the environment, 41 percent in favor of producing energy, and 16 percent with no opinion ("Environmental Protection," 1979). However, 55 percent of those surveyed in June 1981 (Newsweek/Gallup), disagreed with the statement that "in order to help solve our energy problems, we should slow down the rate at which we are working to improve the enviromnent."

Shortly before the accident at Three Mile Island, the public seemed to favor constructing new nuclear plants in the U.S. by a two to one majority (57 to 31 percent). In April 1979, two weeks after the accident, the public was evenly split on the issue (44 percent for versus 43 percent against). A month later, support had increased slightly (52 percent versus 42 percent) (Mitchell, R. C., 1980b). Clear majorities favor restrictions on the operation of nuclear plants pending implementation of stricter controls (66 percent in favor and 24 percent opposed). Another poll taken during this time found that, while Americans believed nuclear power to be important for the "future needs of the nation," 62 percent expressed opposition to nuclear power plants in their own communities as opposed to only 45 percent in 1976 (Gallup, 1979).

The views of residents in the Sunbelt, however, seem to vary somewhat from those of the rest of the nation on the use of nuclear power in the U.S. (see Table 5-7). The East Southcentral area, which includes the Tennessee Valley Authority was strikingly less supportive (7 percent) of constructing more nuclear plants than other parts of the South (25 and 26 percent) or the nation (23 percent). Almost 30 percent said we should stop building nuclear power plants. This may not be unexpected considering the fast rate of nuclear power growth in the TVA area but it certainly raises questions about the future of nuclear power in that area (see Chapter 6).

Figure 5-5 shows the willingness of national respondents to accept each of five different installations--an office building, coal-fired power plant, nuclear power plant, a large factory, or a hazardous waste disposal site. The most objections were raised for the nuclear power plant and the hazardous waste disposal site while the least were associated with the office building. Only 5 percent did not care how near a hazardous waste disposal site was located. Coal-fired plants do not seem to create as many objections as nuclear power plants. While only 28 percent would accept a nuclear power plant within 14 miles of their homes, 63 percent would accept a coal-fired plant (U.S., CEQ, 1980). These relative evaluations stand in contrast to what many experts believe are the actual risks of these facilities; yet citizen

TABLE 5-7: VIEWS ON THE USE OF NUCLEAR POWER IN THE U.S.[a] BY REGION

Statement	South Atlantic	East South-central	West South-central	Rest of Nation
We should continue to build more nuclear power plants as needed	25%	7%	26%	23%
No more new plants should be planned but we should continue to use the ones already in operation and finish those now under construction	49	55	46	46
We should stop building nuclear plants including those under construction and shut down the existing ones as soon as possible	13	29	18	22
Uncertain	11	7	9	8
No Answer	1	2	1	2
(N)	(523)	(176)	(277)	(2,032)

Source: U.S., CEQ, 1980.

[a] Question: At the present time the U.S. has 70 nuclear power plants in operation, plus 91 nonplants which are currently under construction. I am going to read you three statements about the use of nuclear power in the U.S. With which statement do you most agree?

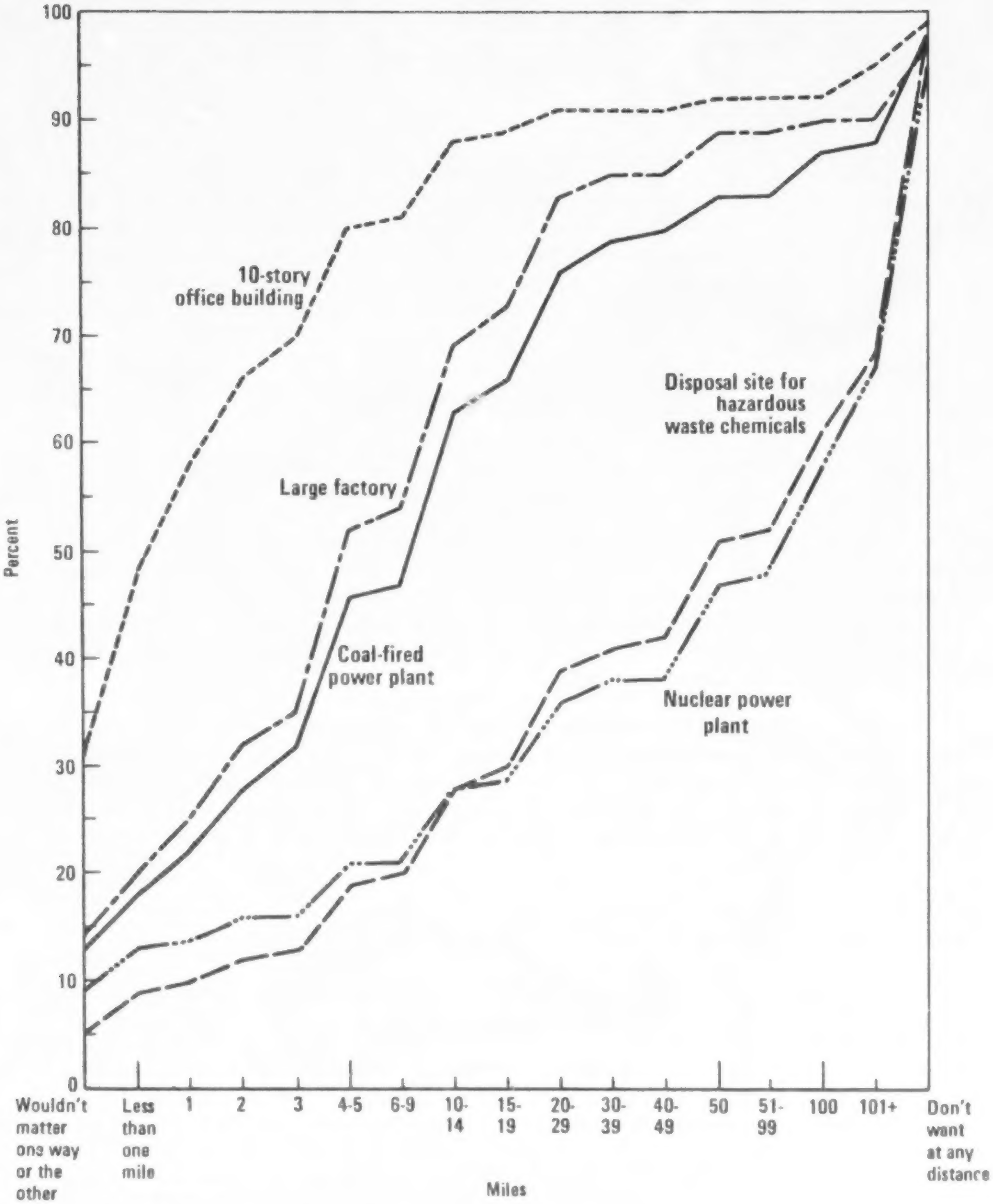

Figure 5-5: Cumulative Percentage of People Willing to Accept New Industrial Installation at Various Distances From Their Homes

Source: Mitchell, R. C., 1980a.

perceptions are important considerations in siting industrial and energy facilities.

E. Chemicals

An increasingly controversial environmental issue is the need for identification and regulation of chemicals which may seriously threaten human health either directly or indirectly (see chapters 7 and 15). When asked whether government should "wait until a chemical is already in use and has been shown to present a problem before taking action" or "conduct an extensive screening program to try and make sure all chemicals are safe before they are used," a substantial majority (82 percent) of the public supported a screening program, while only 8 percent would want the government to wait for a problem (U.S., CEQ, 1980).

When asked what action the government should take regarding chemicals which may not directly affect human health but create environmental risks, the respondents gave mixed answers (see Table 5-8). Majorities favored prohibitions on the disposal of hazardous chemical wastes in the ocean (57 percent) and the release into rivers of industrial wastes harmful to fish (70 percent). However, when asked about pesticides which kill wildlife, a majority (52 percent) said that the government should control but not prohibit their use.

Results from a 1980 Roper survey show that disposal of industrial chemical wastes is a problem that worries 62 percent of the respondents a great deal while, somewhat paradoxically, only 46 percent said that the presence of toxic chemicals such as pesticides or PCB's in the environment worried them a great deal (U.S., CEQ, 1980).

5.2.4 Future Support for the Environment

Public opinion data are better indicators of the current status than of future conditions. However, they are useful for looking at the trends or the direction of change in public attitudes. While the 1970's began with strong public support for the environment, changing economic, social, and environmental conditions have altered the public's perception of national priorities. Some indicators do suggest that the public's support for environmental issues may be sliding somewhat as the nation's economic problems have worsened and implementing effective environmental regulations appears to be an increasingly difficult task.

This does not indicate that environmental protection is no longer supported by the public. On the contrary, public opinion data continue to reflect strong support for the environment as a broad issue of national concern. What it does suggest, however,

TABLE 5-8: SUPPORT FOR GOVERNMENT PROHIBITION OF VARIOUS CHEMICAL RISKS IN PERCENTAGES[a]

	Risks		
Government Actions	Disposal of Hazardous Chemical Wastes in the Ocean	Using Chemical Pesticides Which Kill Wildlife to Increase Crop Production	Releasing Industrial Chemicals Which Harm Fish Into Rivers
Should prohibit	57	36	70
Impose controls but not prohibit	29	52	21
Urge companies to follow certain procedures	6	6	5
Take no action	2	1	1
No opinion	7	4	3

Source: Mitchell, R. C., 1980a.

[a] The sample size for this question equals 736 since only a subsample was queried. The question was: "Even though human beings may not be directly affected, there are various risks that some chemicals pose to the environment. I am going to describe some of these risks and ask you what action, if any, you think the government should take.

1. First, the disposal of hazardous chemical waste far out in the ocean where they harm the ocean environment where they are disposed (read responses)?

2. What about the use of chemicals such as certain pesticides which increase crop production but which kill wildlife (read responses)?

3. And, the current practice of releasing into rivers certain industrial chemicals which have been shown to harm fish (read responses)?

is that the public has become increasingly aware of the costs of cleaning up the environment at a time when the economy seems to be stagnating, energy costs are rising, and threats to national security seem to be increasing. Given limited resources and conflicting priorities, the public seems to be saying that it wants to look more carefully at environmental regulations to be sure they are effective in accomplishing their goal.

5.3 OTHER INDICATORS OF ENVIRONMENTAL SUPPORT

Changes in social values and public attitudes toward the environment can also be determined by looking at such indicators as governmental policies, environmental legislation, scientific and technological activities and expert observations. These indicators provide an additional perspective on the question of how society may respond to environmental problems and issues in the future.

5.3.1 State Responses to Environmental Programs

Recent environmental legislation has emphasized a joint federal/state approach to implementing environmental legislation. Thus, any changes in the way states respond to environmental programs can be an important indicator of environmental support. A recent survey dealing with the states' perspective toward federal programs (U.S., GAO, 1980) suggests that many states in the Sunbelt have placed more emphasis on environmental issues over the past five years (1974-78) than ever before (see Table 5-9). The head of Georgia's lead environmental agency commented that the state "moved aggressively to keep state laws consistent with federal." According to Mississippi's administrator, the state "had been less environmentally aware than other states, but this started to change...as indicated by increasing state legislative support." Louisiana's lead administrator attributed the increased emphasis to "very great concern over [a] solid waste incident--snowball effect." Louisiana, in fact, was the first state in the U.S. to enact comprehensive legislation dealing with hazardous waste disposal (see Chapter 15). Only Tennessee's lead administrator reported "somewhat decreased" emphasis over the past five years and attributed it to the public's concern over "inflation, energy, and other considerations....Their concern for toxics in the environment and their effect on health has remained high but they are confused about them...." Although this administrator predicted "no change" in Tennessee's decreasing emphasis on the environment, all other state environmental administrators in the Sunbelt predicted a continuation or improvement in their state's attention to environmental issues.

TABLE 5-9: EMPHASIS ON ENVIRONMENTAL ISSUES BY STATES IN REGIONS 4 AND 6, 1974-78 and 1979-80

Question: "In your opinion, during the past five years (1974-78) has your state's emphasis on environmental issues...?"[a]

Substantially Increased (Total N=13)	Somewhat Increased (Total N=20)	No Change (Total N=4)	Somewhat Decreased (Total N=8)	Substantially Decreased (Total N=0)
Georgia	Alabama		Tennessee	
Mississippi	Florida			
South Carolina	Kentucky			
Arkansas	North Carolina			
Louisiana	New Mexico			
	Oklahoma			

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[a] Respondents were the administrators for the states' lead environmental agencies; (N = 45).

Question: "Overall, do you feel that during the next two years (1979-80) the emphasis your state places on environmental issues will...?"[a]

Substantially Increase (Total N=1)	Somewhat Increase (Total N=20)	No Change (Total N=17)
	Alabama	Georgia
	Florida	Mississippi
	Kentucky	North Carolina
	South Carolina	Tennessee
	Arkansas	
	Louisiana	
	New Mexico	
	Oklahoma	

Source: U.S., GAO 1980.

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[a] Respondents were the administrators for the states' lead environmental agencies; Texas was the only state in regions 4 and 6 that did not respond; (N = 45).

5.3.2 Legislative Activity

Since mid-century, Congress has enacted important environmental legislation. Air and water quality legislation through the 1950's and 1960's, the National Environmental Policy Act (NEPA) of 1969, and major legislation of the 1970's such as the Resource Conservation and Recovery Act of 1976, the Toxic Substances Control Act of 1976, the Clean Air Act Amendments of 1977, the Clean Water Act of 1977, and Federal Pesticide Act of 1978 comprise a substantial body of laws outlining the nation's environmental objectives and approaches for meeting those objectives (U.S., EPA, 1980). An important question for the 1980's is how Congress will deal with ongoing and new environmental problems.

For several sessions, Congress has debated the issue of cleaning up an increasing number of abandoned or unsafe active chemical dumps being identified across the nation. Congress has now facilitated clean-up action through use of the "superfund," an idea first considered as a way of dealing with ocean oil spills. The legislation assumes that many of the companies that created these dumps no longer exist, so the fund is to be provided by both industry and government as a resource for paying clean-up costs whenever abandoned dumps are found (Mosher, 1980). While this "superfund" legislation, passed in the last week of the 96th Congress, is a beginning mechanism for cleaning up chemical spills and toxic waste dumps, it does not include provisions for oilspills or for compensating victims of injuries or property damage.

The Clean Air Act, up for renewal in 1981, has been targeted by many interest groups for revision. Against the backdrop of a troubled economy, the choices made about this controversial and complex statute should provide a strong indication of the mood of Congress toward environmental protection.

Energy policy is another environmentally-related issue area which has presented difficult legislative choices. One recent issue is the proposed legislation to cap severance taxes on coal. The purpose of the legislation is to keep the consumer's energy prices down. However, it may be fueling the debate between energy-producing and energy-consuming states and may actually work against the nation's policy of increased coal production (Tirk, 1980).

Southern senators have generally been in favor of excluding severance taxes on crude oil and natural gas produced in such states as Texas and Louisiana from any proposed legislation to cap such taxes. They seem more concerned about lowering Montana's 30 percent tax on coal. Montana argues that the federal ceiling is a violation of the state's right to raise revenue, and others point out that capping western coal taxes will price the high-sulfur eastern coal such as that found in Kentucky right out of the market (Tirk, 1980).

5.3.3 Regulatory Reform

Efforts have been made over the past several years to hold down the costs and delays caused by environmental regulation, while still providing adequate protection of human health and the environment. President Ford's Executive Order 11821 (November 1974) required "inflation impact statements" for all major executive agency proposals for legislation and regulations. President Carter's Executive Order 12044 (March 1978) required an analysis of regulations with major economic consequences and semiannual publication of important proposed regulations (U.S., EPA, 1980). The intent of these reforms was to provide information on objectives and benefits of new regulations, identify sections of the economy likely to be affected, explore alternative approaches, and specify the economic effects (Mitchell, M.C., 1980; U.S., EPA, 1980).

The U.S. Regulatory Council composed of 35 officials from regulatory agencies and the White House Regulatory Analysis Review Group (RARG) were established to coordinate and direct these reforms. While efforts to produce cost estimates and in-depth economic analyses of proposed regulations have made slow progress, some positive results have been achieved in the development of new regulatory strategies. EPA seems to have led other agencies in "innovative regulatory approaches" such as the "bubble concept" and emission offset banking programs which permit individual plants greater flexibility in meeting air pollution standards (Mitchell, M. C., 1980; NCAQ, 1981).

5.4 SUMMARY

This brief look at public attitudes and other indicators of change in public priorities suggests that, while some social and economic issues now seem more urgent than specific environmental issues, strong support still exists for broad environmental goals. The ambiguity reflected in some of the public opinion data on "trade-offs" between the environment and energy or the economy seems reasonable given the scientific uncertainty, conflicting information, and lack of public understanding surrounding those issues. In addition, the regulatory framework now in place and the progress made toward meeting environmental goals have enabled the nation to turn its attention to other priorities.

Certainly, there is no conclusive evidence that the public considers human health and environmental protection less important than growth and development issues. Some evidence did suggest, however, that parts of the study area may be less sympathetic to environmental goals and more supportive of industrial development than is the rest of the nation.

However, the public responds to new events and changing needs, both at the national and the community level, especially for such highly salient issues as safe drinking water or hazardous waste disposal. Therefore, even though substantial support for protecting the environment exists, anticipating, monitoring, and understanding changes in social values and public attitudes needs to be a continuing effort.

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CHAPTER 6

ENERGY PRODUCTION AND CONSUMPTION

HIGHLIGHTS

- Status and Trends

1. The Sunbelt is expected to continue to be a major energy consuming and producing region. By 1970, the South was the leading energy consuming region and the area is expected to account for approximately 37 percent of the total national consumption by 1995. Between 1977 and 1995, most of the increase in energy consumption is expected to take place through electricity generation and in the industrial sector.

2. On the whole, the Sunbelt is an energy exporting region. While its share of total U.S. energy production is projected to decline, due primarily to maturing oil and gas fields and the expanded production of western coal, the Sunbelt is expected to remain the primary energy producing region of the U.S.

3. Although the Sunbelt continues to account for a substantial portion of the U.S. petroleum and natural gas reserves, the area's reserves are declining. With a net depletion of reserves in the South and the addition of large reserves in Prudhoe Bay, the Sunbelt's share of U.S. crude oil reserves dropped from 74 percent in 1960 to 44 percent in 1980, while natural gas reserves dropped from 84 percent to 65 percent of the total. Although the Sunbelt's reserves of natural gas liquids also are declining, the area still contains 78 percent of the total U.S. reserves.

4. The Sunbelt is a major petroleum and natural gas producing region. In 1979, the Sunbelt accounted for 60 percent of the total U.S. crude oil production, 82 percent of the natural gas liquids production, and 87 percent of the natural gas production. Production is expected to decline due to the maturing of the oil and gas fields; however, this could change dramatically with the use of enhanced recovery techniques and with production from previously unexplored areas and from unconventional resources.

5. Major increases in wellhead prices have led to unprecedented exploration and development activity. In 1981, 45,979 wells (60 percent of the U.S. total) were projected to be drilled in the South.

6. The Sunbelt contains approximately 26.5 billion tons of recoverable coal reserves; 75 percent of these reserves are located in Region 4. Overall, the proportion of U.S. production from the Sunbelt is projected to decrease slightly over the next 20 years, from 29 percent to 26 percent. However, absolute tonnage produced in the Sunbelt is projected to increase by 65 percent--from 240 million tons to 396 million tons in the year 2000.

7. The Sunbelt is expected to experience a substantial increase in the amount of coal burned for electricity generation. In 1980, the Sunbelt consumed approximately 200 million tons of coal for electricity generation. In addition, by 1988, the total annual demand for coal to supply scheduled new units in the Sunbelt is expected to reach 249 million tons.

8. Parts of the Sunbelt could be involved in synthetic fuel production from coal and oil shale. Over 30 projects using coal as a feedstock are planned or under development in the Sunbelt, including the nation's two largest experimental plants testing advanced coal-to-liquid processes. A number of oil shale processing facilities (Devonian shale) are in the planning stages.

9. The slowdown in construction of nuclear power plants in the Sunbelt (particularly in Region 4) has not taken place to the same degree as in other regions. As of January 1, 1981, seven of the Sunbelt states accounted for 27 percent of the operating units and 31 percent of the U.S. generating capacity.

10. The Sunbelt with its forests, prime cropland, and long growing season is an attractive location for the development of biomass resources for energy. Although biomass resources are not expected to make major contributions to national energy supplies in the next 20 years, locally important developments are taking place in the Sunbelt. Wood is the largest potential source of biomass energy and by 1990 wood could be used to produce about 4.5 billion gallons of methanol in the Sunbelt. Currently, nearly all of the proposed ethanol plants in the Sunbelt will use grain, principally corn, as a feedstock.

11. The South contains about 13 percent (6.7 million acres) of the total U.S. peat lands, mainly in Florida, Louisiana, North Carolina, and Georgia. The estimated 14.7 billion

tons of peat reserves in these four states has the potential for producing approximately 176 quads of energy. Programs are being developed to determine the feasibility of using peat as an energy source and the first commercial program, First Colony Farms, is located in North Carolina.

12. The potential exists in the Sunbelt for the limited development of geothermal energy resources, particularly in Region 6. Hot water and hot dry rock resources are being developed in New Mexico and geopressured zones are undergoing exploration and development along the Texas and Louisiana Gulf Coast. These geopressured resources are particularly attractive because the brine generally is saturated with natural gas (methane).

- Geographic Areas

13. Texas and Louisiana are the main producers of petroleum and natural gas in the Sunbelt. In 1979 they accounted for 81 percent of the crude oil, 79 percent of the natural gas liquids, and 80 percent of the natural gas produced in the South.

14. The Gulf Coast areas of Alabama, Florida, and Mississippi, the Eastern Overthrust Belt, the Deep Anadarko Basin in Oklahoma, and the Tuscaloosa Trend in Louisiana are undergoing substantial oil and gas exploration and development. Currently producing areas also are experiencing a high level of activity. Of the 45,979 wells projected for the Sunbelt in 1981, 39,402 (86 percent) were expected to be drilled in Texas, Oklahoma, and Louisiana.

15. Within Region 4, production of coal from surface mining is expected to decrease, while underground mining is projected to increase substantially between 1980 and 2000. Most of the production will be accounted for by Kentucky. In Region 6, coal resources in New Mexico and in the Lignite Belt of Texas are expected to undergo substantial development from surface mining. Production is projected to increase from 37 million tons per year in 1980 to 162 million tons per year in 2000.

16. New Mexico is the only state in Region 6 that is not projected to experience a large increase in coal-fired electric generating capacity between 1979 and 1988. Of the 58 new units and 32,651 MW of new capacity scheduled for Region 6, approximately half is projected for Texas.

17. The distribution of projects in the Sunblet for producing synthetic fuels from coal is relatively even--18 in Region 4 and 15 in Region 6. However, 52 percent of the projects

are concentrated in Kentucky (9) and along the Texas/Louisiana Gulf Coast (8). Eastern Tennessee, northern Alabama, and northwestern New Mexico also have multiple sites.

18. Kentucky and Tennessee are the most likely Sunbelt states for the development of Devonian oil shale resources. Together, these states contain an estimated 234 billion barrels of shale oil.

19. Nuclear power will continue to be an important source of energy in Region 4, particularly in the area supplied by the Tennessee Valley Authority and the Carolinas. Although the states in Region 6 are expected to rely very little on nuclear power as a source of energy, northwest New Mexico and southcentral Texas are important uranium mining and milling areas. In addition, the salt domes of the Texas and Louisiana Gulf Coast are being considered as storage sites for high level radioactive wastes.

20. The development of peat as an energy source could take place along the coastal areas of North Carolina and Louisiana and in the southern portion of Florida; however, North Carolina is the most likely area for development.

21. Some areas will be more heavily involved in energy-related activities than others and could experience multiple energy developments. For example, Kentucky and the Gulf Coast of Texas and Louisiana could experience increased coal mining, synthetic fuel production from coal, oil and gas exploration and recovery, increased use of coal-fired power plants, and conversion of biomass to liquid fuels. In addition, the Gulf Coast has the potential for development of geothermal resources.

• Key Problems and Policy Issues

22. Fuel switching presents economic and environmental problems for Region 6, especially in Texas and Oklahoma. Except for Florida and Mississippi, fuel switching will not be a major problem in Region 4.

23. The environmental, occupational, and human health impacts of coal production are expected to increase in Kentucky, Alabama, Texas, and New Mexico due to expanded production to meet demands for electricity generation and as feedstock for synthetic fuels.

24. Disposition of waste products from various energy developments and facilities (oil and gas production, nuclear and coal-fired power plants, synthetic fuel plants, biomass

and geothermal) will be a greater problem in the future. For example, major waste products include spent nuclear fuel and low level wastes; scrubber sludge from coal-fired power plants; brine and drilling mud from oil, gas, and geothermal drilling; ash and sludges from coal synfuel plants; and spent shale from oil shale plants.

25. While oil and gas production in the Sunbelt is expected to decrease, drilling activity is projected to increase--primarily in Texas, Oklahoma, and Louisiana. This activity could lead to such environmental problems as disposal of drilling muds and brine and potential ground water contamination. For example, in Oklahoma, approximately 300 communities depend on ground water to meet all of their water needs, and about 80 percent of the water used in irrigation comes from underground sources. Virtually all of the ground water to supply these communities and for irrigation is in the western half of the state, an area of increasingly heavy drilling activity.

26. Current regulations, particularly the Clean Air Act, could inhibit the development of the synthetic fuel industry and make it more difficult to site the increasing number of coal-fired power plants. Increases in NO_x, SO_2, particulates, and ozone could be a problem in the eastern and Gulf Coast states, thus making siting difficult.

27. The lack of comprehensive government strategy for the permanent disposition of spent nuclear fuel and low-level wastes could have a number of negative impacts. Some plants are close to exhausting on-site storage capacity. This will require transportation to an interim storage facility or shutdown of the plant.

CHAPTER 6

ENERGY PRODUCTION AND CONSUMPTION

6.1 INTRODUCTION

The Sunbelt is expected to continue to be a major energy consuming and producing region. For the past 20 years, energy consumption in the Sunbelt has grown at a faster rate than any other region of the country. Since adequate energy supplies are essential to population growth and economic development in the Sunbelt, the region is expected to maintain its position as the leading energy consuming region, accounting for one-third of the total U.S. energy consumption.

The oil and gas fields of the Southwest and the coal fields of the Southeast historically have produced much of the energy consumed in the United States. In order to meet nationwide and regional demands, the production of several resources is expected to increase. For example, coal production and use is projected to increase dramatically in the Southwest through the year 2000. The capacity for producing synthetic fuels from coal and oil shale is developing in Appalachia, particularly in Kentucky and along the Texas and Louisiana Gulf coast. While national plans for the use of nuclear energy have been curtailed significantly in recent years, the Southeast is moving ahead with the construction of nuclear reactors. Due to extensive timberland and prime cropland, the ability to produce energy from renewable biomass resources is being developed in many areas of the Southeast. Peat is being considered as a source of energy in some of the coastal states, and North Carolina is the site of the nation's first major peat energy project. Finally, geothermal resources are being explored and developed in the Southwest as a source of electrical, mechanical, and chemical energy.

These energy developments will not only be important to state and local economies, but they will increase our ability to pursue an independent foreign policy, reduce our balance of payments deficit, reduce our dependence on foreign oil and gas, and ensure adequate energy supplies for a growing economy.

However, energy developments could be constrained by several environmental concerns, especially those related to water resources and air quality. For example, southcentral Texas is expected to experience multiple energy developments (oil and gas, uranium, geothermal, synthetic fuels, lignite) in an area already suffering from inadequate water supply, ground water overdraft, pollution of surface water, and along the coast, saltwater intrusion. In addition, this area is projected to experience large increases in sulfur dioxide (SO_2) emissions--as much as 700 percent in the Austin area. This type of situation is not uncommon in the Sunbelt and suggests the need for policies and strategies that would allow for development while minimizing adverse environmental impacts.

This chapter discusses energy production and consumption trends in the Sunbelt and provides an overview of the current and future trends and potential environmental issues associated with seven energy developments: oil and gas, direct use of coal, synthetic fuels from coal and oil shale, nuclear energy, renewable biomass, peat, and geothermal resources.

6.2 SOUTHERN ENERGY TRENDS

6.2.1 Introduction

The South has enjoyed several decades of relatively rapid economic development. This growth has, in part, been facilitated by lower energy costs, as compared to other regions of the country. This factor, coupled with lower labor costs, has kept the South in an advantageous position to attract new and expanded industry. In the future, energy will no longer be cheap nor as readily available. Thus, the southern economy is vulnerable to economic dislocations caused by sudden increases in energy prices or uncertainty of long-term energy availability (SSEB, 1981). Nevertheless, this area is the most important region of the nation in terms of energy production and resources. For example, the South is the nation's leading producer of oil, natural gas, and coal and leads the nation in the amount of nuclear-generated electricity. The ability of the South to maintain its economic growth and competitiveness in the coming decades depends, in great part, on energy policy and developments.

As general background to the specific energy resources discussed in the remainder of this chapter, this section will provide a brief overview of energy consumption and production trends in the Sunbelt. Of course, projections about the supply, demand, and use of energy resources in the future depend on assumptions and information that become increasingly uncertain over time, including: the sizes of the resource bases, the ease with which resources can be discovered, applicable environmental laws and other government policies, the rates at which proved reserves will be produced, the costs of recovery operations, and the future process for various energy forms. Further, the nature and degree of uncertainty varies substantially among alternative energy resources.

Therefore, while the following projections are taken from the most recent data available and can be considered reasonable in light of current knowledge, the reader should recognize the wide variety of sources of uncertainty associated with such projections.

6.2.2 Consumption

The demand for energy in the United States increased sporadically during the 1970's before peaking at about 79 quadrillion Btu (quads or Q's) in 1979. Most of the growth in energy demand resulted from increased consumption in the transportation sector and from the generation of electric power. However, during the past two years energy consumption actually has decreased. Following a 3.5 percent drop in consumption in 1980, total energy requirements for 1981 are expected to fall another one percent to 75.5 quads. During the first seven months of 1981, the U.S. used 43.9 quads of energy, 2.2 percent less than during the same period in 1980 (BNA, 1981).

Historically, the U.S. economy has been based on the use of increasing quantities of energy for the production of goods and services and there has been a close relationship between increase in real Gross National Product (GNP) and energy consumption. Through the 1970's, and particularly over the past few years, there has been a dramatic shift in this relationship. Price-induced conservation and improved energy efficiency have resulted in reduced energy requirements in spite of the growth in economic activity. Between 1979 and 1981, total energy demand will have decreased by 4.5 percent, while GNP increased by 2.4 percent. Energy consumption per dollar of real GNP (1972 dollars) is expected to decline for the eleventh consecutive year. In 1970 62,400 Btu of energy was consumed per dollar of GNP; in 1981, it is forecast to fall to 49,700 Btu per dollar, the lowest level recorded (OGJ, 1981).

While energy consumption will not continue to decrease indefinitely, conservation and increased energy efficiency have reduced expectations about how much energy will be required in future years to ensure economic growth. Until recently, it was widely projected that the U.S. would require 150 quads or more of energy annually by the year 2000; some estimates ranged as high as 200 quads. In 1979, projections for the year 2000 clustered in range of 115 to 130 quads. The doubling of world oil prices during that year caused further cuts in projected demand. In the third National Energy Policy Plan, the Department of Energy (DOE) projects that demand will total about 100 quads in 2000 with a possible range of from 97 to 107 quads. Similarly, Standard Oil of Ohio expects demand to reach about 100 quads in 2000 (OGJ, 1981b, p. 149). In 1976, Shell Oil Company estimated U.S. energy demand by 1990 to be about 110 quads; in 1980 they revised this estimate to 84 quads. Exxon recently reduced its forecast for 1990 from 102 quads to 81 quads. These projections are slightly lower than DOE's mid-range projection of 87 quads (BNA, 1981b; U.S., Pres. Comm., 1980).

According to the third National Energy Policy Plan, total U.S. energy consumption is expected to increase at about 1 to 1.5 percent per year to 2000. However, energy consumption trends will vary regionally. Figure 6-1 shows regional energy consumption as a proportion of total U.S. consumption. Energy consumption in the South has grown at a faster rate than in the other regions of the nation. In 1960, the South accounted for about 27 percent of the total national energy consumption and ranked third behind the northcentral and northeast sections of the country. By 1970 the South was the leading energy consuming region, and is projected to continue to increase its proportion of the total U.S. consumption. The Sunbelt area is expected to account for approximately 37 percent of total consumption by the year 1995. The West is the only other region that is increasing its share of the energy consumed, but the rate of growth in consumption is much slower than in the South.

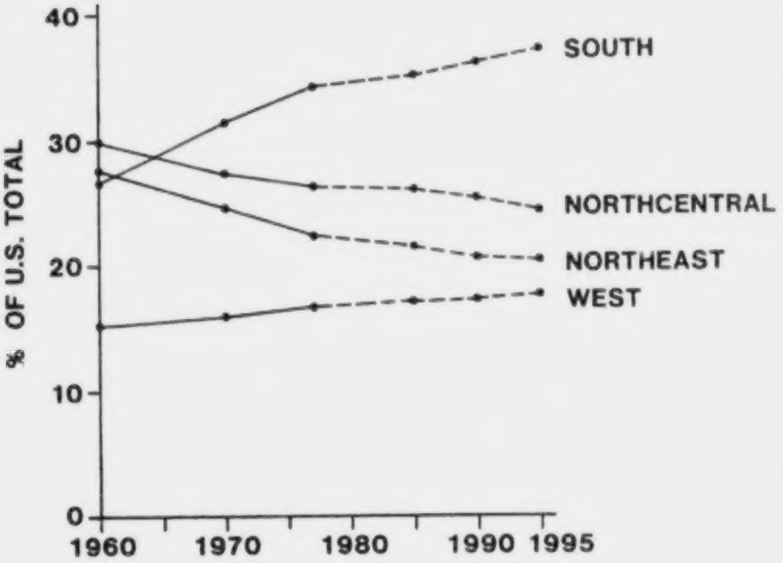

Figure 6-1: Consumptive Energy Use

Source: U.S., DOE, EIA, 1980a; Galliker, 1979.

While the South has been increasing its share of the total U.S. energy consumption, the region generally has followed the national trends with respect to consumption by end-use sector (Table 6-1). Virtually all of the growth in energy demand during the 1970's occurred in the generation of electric power and in the transportation sector. This trend is projected to change somewhat in the future. Between 1977 and 1995, most of the increase in energy consumption is expected to take place through electricity generation and in the industrial sector. Within the Sunbelt, these two sectors are expected to account for approximately 77 percent of the increase in energy consumption between 1977 and 1995. Both regions 4 and 6 will mirror the national trends, with the largest increases due to electricity generation.

The mix of fuels consumed can be an important determinant of economic development and of potential environmental consequences. As indicated by the data in Table 6-2, the mix of major energy sources did not change much between 1960 and 1977. Overall, the South was heavily dependent on natural gas and oil with little use of nuclear power. However, within the South, there were some rather significant differences. In 1977 Region 6 relied almost exclusively on natural gas (64 percent) and oil (32 percent), with natural gas being the most important source of energy. While 64 percent of Region 4's energy came from these same sources, the Southeast was more dependent on oil (48 percent) rather than natural gas (16 percent). Further, about a third of the energy consumed in Region 4 was supplied by coal, compared to only 4 percent in Region 6.

In the future, the relative mix of energy sources is projected to change dramatically. In the Sunbelt as a whole, the use of natural gas and oil is expected to decrease, while the use of coal and nuclear power increases. By 1995, the mix of major fuel sources in the South is projected to be virtually the same as the mix in the nation as a whole. However, differences between regions 4 and 6 will continue to exist. In Region 4, the use of natural gas is expected to remain relatively stable, while the use of oil decreases and coal and nuclear power become more important. Region 6 is projected to decrease its dependence on natural gas and oil from 96 percent to 63 percent between 1977 and 1995 and undertake a major shift toward the use of coal.

6.2.3 Production

Even though the United States only has five percent of the world's population, it consumes 30 percent of the world's energy. In the last two years, considerable progress has been made in energy conservation and production. For example, since the cutoff of Iranian oil in 1979, U.S. demand for oil has dropped two million barrels per day (MMbbl/d). In addition, U.S. oil and natural gas production has held fairly steady after years of

TABLE 6-1: GROSS ENERGY CONSUMPTION BY END-USE SECTOR[a] (quadrillion Btu's)

Region	1960	1970	1977	1985	1990	1995
Region 4						
Residential	0.74	1.19	1.26	1.38	1.42	1.46
Commercial	0.39	0.76	1.01	1.06	1.22	1.39
Industrial	1.74	2.55	2.64	2.74	3.26	3.71
Transportation	1.39	2.60	3.41	3.28	3.47	3.63
Electricity Generation	0.99	2.14	3.18	4.23	4.99	5.58
Other[b]	--	--	--	0.09	0.09	0.08
Total[c]	5.27	9.24	11.49	12.78	14.45	15.85
Region 6						
Residential	0.53	0.88	0.99	1.04	1.09	1.12
Commercial	0.33	0.71	0.84	0.75	0.82	0.89
Industrial	3.49	7.04	7.86	6.47	8.06	8.82
Transportation	1.21	2.12	2.98	2.95	3.06	3.15
Electricity Generation	0.55	1.48	2.26	2.80	2.86	3.56
Other[b]	--	--	--	0.72	0.71	0.47
Total[c]	6.11	12.22	14.95	14.73	16.60	18.01
Sunbelt						
Residential	1.27	2.07	2.25	2.42	2.51	2.58
Commercial	0.72	1.47	1.85	1.81	2.04	2.28
Industrial	5.23	9.59	10.50	9.21	11.32	12.53
Transportation	2.60	4.72	6.39	6.23	6.53	6.78
Electricity Generation	1.54	3.62	5.44	7.03	7.85	9.14
Other[b]	--	--	--	0.81	0.80	0.55
Total[c]	11.38	21.46	26.44	27.51	31.05	33.86
U.S.						
Residential	7.18	10.08	10.28	10.57	10.66	10.62
Commercial	4.40	7.37	7.97	7.13	7.63	8.09
Industrial	15.39	23.07	23.22	20.09	23.67	25.98
Transportation	9.64	15.86	19.50	18.27	18.61	18.65
Electricity Generation	5.73	11.69	15.87	19.75	22.64	25.33
Other[b]	--	--	--	2.43	2.49	2.33
Total[c]	42.36	68.07	76.85	78.24	85.70	91.00

Source: Historical data computed from Galliker, 1979. Projections computed from U.S., DOE, EIA, 1980a.

[a] The projections do not include solar or geothermal in electricity generation or synthetic fuels consumption. Including these end users, the total gross energy consumption for the U.S. in 1985 is 78.51 Q's; 1990, 86.89 Q's; 1995, 93.52 Q's.

[b] Includes refinery oil product consumption and refinery gas consumption.

[c] Columns may not add to totals due to independent rounding.

TABLE 6-2: ENERGY CONSUMPTION BY MAJOR FUEL SOURCES[a] (percent)[b]

Region	1960	1970	1977	1985	1990	1995
Region 4						
Natural Gas	22	26	16	19	16	15
Oil[c]	45	42	48	33	29	29
Coal	32	31	30	36	39	40
Nuclear	--	<1	6	13	15	17
(Quads)	4.64	8.45	10.58	12.40	13.92	15.42
Region 6						
Natural Gas	66	74	64	53	46	40
Oil[c]	33	24	32	27	26	23
Coal	1	2	4	18	24	32
Nuclear	--	--	<1	2	3	5
(Quads)	4.81	9.97	12.27	14.67	16.24	17.69
Sunbelt						
Natural Gas	44	52	41	37	32	28
Oil[c]	39	32	39	29	28	25
Coal	17	15	16	26	31	36
Nuclear	--	<1	3	7	9	10
(Quads)	9.45	18.42	22.85	27.07	30.16	33.11
U.S.						
Natural Gas	28	36	29	30	27	25
Oil[c]	45	42	46	36	33	29
Coal	27	22	21	27	31	35
Nuclear	--	<1	4	7	10	10
(Quads)	37.34	60.17	68.6	75.09	82.51	87.65

Source: Historical data computed from Galliker, 1979. Projections computed from U.S., DOE, EIA, 1980a.

[a] This does not include hydroelectric, solar, geothermal or synthetic fuels consumption. The U.S. total fuel use from all sources is projected to be 78.51 Q's in 1985; 86.89 Q's in 1990; 93.52 Q's in 1995.

[b] Columns may not add to 100 percent due to rounding.

[c] Oil includes distillate, residual, gasoline, jet fuel, and other petroleum.

decline (Hartley, 1981). Thus, we not only began to use less, but also to produce a larger proportion of the oil and gas we use.

While the overall energy picture is getting better at the national level, most states will remain net importers of energy. Although the Sunbelt is very diverse and includes both energy exporting and energy importing states, on the whole it is an energy exporting region. In 1979, this region produced approximately 60 percent of the nation's crude oil, 82 percent of the natural gas liquids, 87 percent of the natural gas, and 29 percent of the coal. On the other hand, in 1977 the Sunbelt states accounted for approximately 28 percent of the U.S. crude oil consumption, 47 percent of the natural gas consumption, and 25 percent of the coal consumption. The energy producing character of the Sunbelt is due to Kentucky, Louisiana, New Mexico, Oklahoma, and Texas; the remaining states are net energy consumers (Boercker et al., 1977). The South's share of the total U.S. energy production is projected to decline over the coming decades, due primarily to the maturing of the oil and natural gas fields and the expanded production of western coal. Nevertheless, the South is expected to remain the primary energy producing region of the U.S.

In the future, greater reliance will be placed on electricity to replace fuel forms either too costly or which have an uncertain supply availability. Although the rate of growth in demand has slowed dramatically compared to the past several decades, electricity will remain a key energy form for the South and significant amounts of new generating capacity will be needed. In 1980, the South accounted for 35 percent of the total U.S. electricity generation capacity; 58 percent of the South's capacity is located in Region 4 (Table 6-3). Of the new capacity projected to be ready for commercial service by 1990, 52 percent will be in the South. None of the new power plants will use natural gas and only 12 of the 181 projected units are to use oil. Almost all of the future electricity generating capacity will rely on coal and nuclear power--94 percent of the new capacity in Region 4 and 98 percent of the capacity in Region 6. However, the relative mix of the fuels will differ significantly between the two areas. Within Region 4, 50 percent of the new capacity will be nuclear and 44 percent is projected to be coal. On the other hand, Region 6 will be much more dependent on coal (69 percent) rather than nuclear (29 percent) for new generating capacity.

Overall, while total demand for energy in the South is projected to grow at a slower pace than in recent years, it will continue to grow. Energy production is expected to be adequate throughout the 1980's, although the possibility of spot shortages of certain fuels exists (SSEB, 1981).

TABLE 6-3: ELECTRICITY GENERATION: CAPACITY AND UNITS BY FUEL TYPE

Region	1980 Capacity[a] (megawatts)	Number of Units	Projected Additional Capacity[b] (megawatts)	Number of Additional Units
Region 4				
Coal	65,096	265	34,387	55
Oil	26,823	456	1,490	9
Gas	5,639	121	0	0
Hydroelectric	12,586	519	2,618	25
Nuclear	15,908	18	39,094	32
Other	716	9	0	0
Total	126,768	1,388	77,589	121
Region 6				
Coal	19,674	42	23,614	40
Oil	5,071	189	190	3
Gas	60,040	737	0	0
Hydroelectric	2,574	115	680	7
Nuclear	1,861	2	9,867	10
Other	1,390	12	0	0
Total	90,610	1,097	34,351	60
Sunbelt				
Coal	84,770	307	58,001	95
Oil	31,894	645	1,680	12
Gas	65,679	858	0	0
Hydroelectric	15,160	634	3,298	32
Nuclear	17,769	20	48,961	42
Other	2,106	21	0	0
Total	217,378	2,485	111,940	181
U.S.				
Coal	253,069	1,333	120,528	230
Oil	148,084	4,529	7,705	101
Gas	76,454	1,700	546	6
Hydroelectric	76,407	3,209	16,719	141
Nuclear	57,859	74	66,599	105
Other	4,592	65	2,155	21
Unknown	22	12	350	6
Total	616,487	10,922	214,602	610

Source: U.S., DOE, EIA, 1981a.

[a] Includes existing, standby, and shutdown units.

[b] Capacity scheduled for commercial service through 1990.

6.3 PETROLEUM[1] AND NATURAL GAS

6.3.1 Introduction

The United States is heavily dependent on petroleum and natural gas and will remain so through the end of this century. The Sunbelt, particularly Region 6, is a major petroleum and natural gas producing and consuming region. While the Sunbelt's contribution to the total U.S. production of petroleum and natural gas will remain substantial, production is expected to continue to decline gradually over time. At the same time, consumption of petroleum and natural gas in the Sunbelt is projected to decline --from 80 percent of total energy consumption in 1977 to 53 percent in 1995.

This section will discuss the availability of petroleum and natural gas resources in the Sunbelt and highlight the current and future status of production and exploration activities. The section will conclude with a brief discussion of some of the environmental issues associated with the development of petroleum and natural gas resources.

6.3.2 Resource Distribution

Prior to the Arab oil embargo, little attention was given to the fact that the petroleum and natural gas resources in the United States were limited and not renewable. Since that time, considerable effort has been devoted to assessing the remaining resources and the consequences for future production. Table 6-4 presents the status of proved reserves of petroleum and natural gas in the Sunbelt and the U.S. for the past 20 years. For the past 10 years, oil and gas reserves in the U.S. have been declining steadily. However, increased drilling activity has helped stabilize U.S. reserves during the past couple of years. For example, proved reserves of crude oil, natural gas liquids, and natural gas were almost unchanged in 1980 compared with 1979; reserves of crude oil and natural gas declined by less than 1 percent, while natural gas liquids increased by 2 percent (BNA, 1981c).

The Sunbelt has accounted for a major portion of the U.S. petroleum and natural gas reserves. In 1960, this area contained approximately 74 percent of the proved reserves of crude oil in the U.S. With a net depletion of reserves in the South and the addition of large crude oil reserves in Prudhoe Bay, the Sunbelt's

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[1] Proved reserves are identified deposits of resources that are recoverable using current technology and under present economic conditions. Petroleum includes crude oil and natural gas liquids.

TABLE 6-4: PROVED RESERVES[a] OF PETROLEUM[b] AND NATURAL GAS

Region	Crude Oil (million barrels)			Natural Gas Liquids (million barrels)			Natural Gas (billion cubic feet)		
	1960	1970	1980	1960	1970	1980	1960	1970	1980
Region 4									
Alabama	c	65	54	c	21	226	c	162	636
Florida	c	c	134	c	c	27	c	c	84
Kentucky	129	61	35	49	48	25	1,144	978	508
Mississippi	407	355	202	36	23	20	2,542	1,334	1,769
Total	536	481	425	85	71	298	3,686	2,474	2,997
Region 6									
Arkansas	302	130	107	27	12	16	1,460	2,581	1,774
Louisiana[d]	4,785	5,710	2,751	1,433	2,567	1,346	63,386	82,957	47,325
New Mexico	1,084	761	547	485	559	541	15,604	13,290	13,287
Oklahoma	1,791	1,351	930	338	359	604	17,311	16,954	13,138
Texas[d]	14,758	13,195	8,206	3,596	3,330	2,452	119,489	106,353	50,287
Total	22,720	21,147	12,541	5,879	6,827	4,959	217,250	222,135	125,811
Sunbelt Total	23,256	21,628	12,966	5,964	6,898	5,257	220,936	224,609	128,808
U.S. Total	31,613	39,001[e]	29,805	6,816	7,703	6,728	263,759	290,746[f]	199,021[f]

Source: U.S., DOI, BuMines, 1961, Vol. 2; API, 1971; OGJ, 1981c.

[a] Proved reserves are those resources at the end of any given year which geological and engineering data demonstrate can be removed from known reservoirs under existing economic and operating conditions.

[b] Petroleum includes crude oil and natural gas liquids.

[c] Data not available or not disaggregated.

[d] Includes offshore reserves.

[e] Includes 10.1 billion barrels of estimated proved reserves in Prudhoe Bay discovered in 1968. These reserves not available until completion of the Alaska pipeline in 1977. These reserves also are included in the 1980 total.

[f] Includes 26 trillion cubic feet of estimated proved reserves in Prudhoe Bay discovered in 1968. These reserves are not yet available due to lack of transportation facilities.

share of the total U.S. proved reserves dropped to 44 percent by 1980.

Although total U.S. crude oil reserves were only reduced by five million barrels (MMbbl) during 1980, the Sunbelt reserves were reduced by 218 MMbbl.[1] Only Alabama, Arkansas, Florida, and Kentucky did not have a net reduction in reserves. Together, they accounted for a 25 MMbbl increase. Texas, Louisiana, and Oklahoma continue to account for most of the Sunbelt reserves--92 percent of the crude oil reserves in 1980, down only slightly from 94 percent in 1960.

Although the Sunbelt's reserves of natural gas liquids also are declining, the area still contains 78 percent of the total U.S. reserves. Most of the South's reserves, 72 percent, are accounted for by Texas and Louisiana, however, the proportion located in these states is declining. In 1980, the natural gas liquids reserves in Texas and Louisiana were reduced by 30 MMbbl and 78 MMbbl respectively. Oklahoma, on the other hand, increased its reserve base by 21 MMbbl and now accounts for 10 percent of the reserves, compared to 5 percent 10 years ago. Overall, the Sunbelt experienced a net reduction of 55 MMbbl of natural gas liquids during 1980, while proved reserves for the U.S. as a whole increased by 113 MMbbl.

Natural gas reserves have followed the same general decline as the reserves of crude oil and natural gas liquids. Including 26 trillion cubic feet (tcf) of estimated reserves in Prudhoe Bay, the total U.S. proved reserves of natural gas amounted to approximately 199 tcf in 1980. The Sunbelt states accounted for 65 percent of these reserves; 19 percent less than their share in 1960. Ninety-eight percent of the reserves in the Sunbelt are located in Region 6. Together, Texas (39 percent) and Louisiana (37 percent) account for 76 percent of the reserves, while New Mexico and Oklahoma each contain another 10 percent.

During 1980, the total base of natural gas reserves in the U.S. declined by 1.98 tcf. The Sunbelt reserves, however, declined by 6.2 tcf. This was due, in large part, to a reduction of 5.45 tcf of reservesalmost evenly divided between Texas and Louisiana.

There is a possibility that total natural gas resources far exceed any previous estimates. For many years it was assumed that natural gas stopped at about the same depth as oil. Today, natural gas is being discovered at much greater depths and new finds are occurring at an increasingly rapid rate. Exploration in the

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[1] The discussion of changes in Sunbelt reserves of crude oil, natural gas liquids, and natural gas is taken largely from OGJ, 1981c.

Texas and Oklahoma portions of the Anadarko Basin is booming and the Eastern Overthrust Belt running from Alabama to New York has been receiving increasing attention. For example, the Anadarko Basin has been estimated to contain 15 to 100 tcf of natural gas reserves. Further, the estimates contained in Table 6-4 do not include estimates of uncoventional natural gas--resources in tight sandstones, geopressured water reservoirs, coal beds, and other sources not now being produced on a wide-scale basis because of economic or technical reasons. The Deep Tuscaloosa Trend in Louisiana has been estimated to contain as much as 24,000 tcf of unconventional natural gas resources, or about 1,000 years supply at current consumption rates (SSEB, 1981).

6.3.3 Current and Future Status

A. Production

In the mid-1970's, many felt that price would largely determine the level of exploration and development activity and the rate of production from a diminishing but still very large petroleum and natural gas resource base. Since then, however, there has been a growing awareness that these resources are finite and and that their production potential is limited. Of course, price will continue to have a major influence on future investment decisions and the rate of development of future petroleum and natural gas supplies. However, production must take place within the constraints of a diminishing resource base and within the technological and institutional constraints imposed on resource development (U.S., GAO, Comp. Gen., 1979).

In 1970, U.S. petroleum production peaked at about 4.1 billion barrels for the year (Table 6-5). Most of this production, 3.5 billion barrels, was in the form of crude oil. Depsite an upsurge in drilling activity, production continued to decline to approximately 3.5 billion barrels of crude oil and natural gas liquids by mid-1977. In 1978, the beginning of production from Prudhoe Bay reversed the overall decline in U.S. production, but production from the lower 48 states continued to slide. However, with the decontrol of crude oil prices in January 1981 and the increased drilling activity that followed, the general decline in lower 48 crude production is slowing. In 1981, crude oil production actually turned upward (OGJ, 1981d).

The Sunbelt is a major petroleum and natural gas producing region and will continue to be an important source for U.S. supply for the foreseeable future. In 1979, the Sunbelt accounted for 60 percent of the crude oil produced in the U.S and 82 percent of the natural gas liquids. Although the Sunbelt production of petroleum in 1979 accounted for a smaller percentage of the total U.S. production than in 1960, absolute production actually increased, from 2,112 to 2,332 MMbbl. Of the petroleum produced in the Sunbelt,

TABLE 6-5: PETROLEUM AND NATURAL GAS PRODUCTION

Region	Crude Oil[a] (million barrels)			Natural Gas Liquids (million barrels)			Net Natural Gas[b] (billion cubic feet)		
	1960	1970	1979	1960	1970	1979	1960	1970	1979
Region 4									
Alabama	7	7	19	c	0.2	c	c	c	87
Florida	0.4	3	47	c	c	c	c	c	50
Kentucky	21	12	5	3	3	c	73	78	60
Mississippi	52	65	38	3	2	c	186	133	182
Tennessee	0.02	0.3	0.6	c	c	c	c	c	1
Total[d]	80	87	110	6	5	4[e]	259	211	380
Region 6									
Arkansas	30	18	19	2	2	1	83	182	110
Louisiana	401	907	490	82	250	120	3,056	7,942	7,292
New Mexico	107	128	80	28	49	45	779	1,142	1,186
Oklahoma	193	224	144	28	40	51	994	1,725	1,862
Texas	927	1,250	1,016	228	336	252	5,903	8,458	7,202
Total	1,658	2,527	1,749	368	677	469	10,815	19,449	17,652
Sunbelt Total	1,738	2,614	1,859	374	682	473	11,074	19,660	18,032
U.S. Total	2,575	3,517	3,121	431	748	578	13,090	22,410	20,638

Sources: API, 1978 and updates; U.S., DOI, BuMines, 1961, 1971; AGA, 1980; U.S., DOE, EIA, 1980b, 1981b.

[a] Includes lease condensate.

[b] Net production includes marketed withdrawals and gas that is ventd or flared. It does not include gas injected into the reservoirs for repressuring.

[c] Data not available or not disaggregated; together Alabama and Florida produced 4,000 barrels of natural gas liquids in 1960.

[d] Total may not add to sum of columns due to rounding.

[e] Combined production of Mississippi and Alabama.

Texas and Louisiana have been the leading suppliers. In 1979, these two states accounted for 81 percent of the crude oil and 79 percent of the natural gas liquids produced in the Sunbelt.

At present production levels, the proved crude oil reserves in the Sunbelt would last approximately seven years, while the reserves of natural gas liquids would last about eleven years. Unless major new fields are discovered, resource limitations and technological factors are likely to be important determinants of future petroleum production from the Sunbelt. In addition, the economic climate, the price of oil and gas, environmental concerns, and other institutional constraints will affect activity levels and production rates.

Although the Sunbelt's production of crude generally has been declining over the past ten years, the area's refining capacity has been increasing (Table 6-6). In 1969, the South had a crude oil refining capacity of 5.2 MMbbl/d; by 1981 this was expected to be approximately 9.3 MMbbl/d. Thus, in 1981, the South accounted for 51 percent of the total U.S. crude oil refining capacity.

Not unexpectedly, most of the Sunbelt's refining capacity is located in the major producing states of Louisiana and Texas. Between them, they account for 82 percent of the refining capacity in the Sunbelt and 42 percent of the total U.S. capacity. Primarily due to environmental and regulatory considerations, any significant additions to the nation's refinery capacity are expected to come largely from expanding the existing refineries, rather than from new refineries built in areas where refining presently does not exist. Consequently, the outlook for future expansion of the Texas and Louisiana refinery capacity depends greatly on the cost of processing crude oil (including the cost of transportation) in these states as compared to other existing refining centers around the country (SSEB, 1981).

Historically, natural gas resources were developed in association with petroleum resources. In the early days of the petroleum industry, gas was a by-product that had small markets in the producing areas and most of the associated gas was flared. Nonassociated or dry gas reservoirs were, for the most part, accidental finds in the search for oil. However, long-distance pipelines and the use of gas as a petrochemical feedstock opened up vast markets for natural gas.

Nationally, production of natural gas peaked in 1973 at 22.6 tcf and since then has fallen at a rate of about 3 percent per year (U.S., GAO, Comp. Gen., 1979). In addition to petroleum, the Sunbelt has been, and continues to be, a major producer of natural gas. As indicated in Table 6-5, in 1960, 85 percent of the natural gas produced in the United States came from the Sunbelt. In 1979, the area produced 18 tcf and accounted for 87 percent of the

TABLE 6-6: OPERATING REFINERIES IN THE SUNBELT

Region	January 1, 1969		January 1, 1981	
	Number of Plants	Crude Capacity (bbl/cd)^b	Number of Plants	Crude Capacity (bbl/cd)^b
Region 4				
Alabama	5	27,870	6	147,235
Florida	1	3,000	2	41,400
Georgia	2	8,600	2	28,750
Kentucky	4	129,000	4	244,100
Mississippi	4	168,700	8	371,525
North Carolina	-	-	1	11,900
Tennessee	1	27,500	1	49,000
Total	17	364,670	24	893,910
Region 6				
Arkansas	6	91,000	4	65,200
Louisiana	17	1,191,150	33	2,449,274
New Mexico	6	42,700	7	114,388
Oklahoma	14	449,300	12	567,270
Texas	48	3,126,679	59	5,259,990
Total	91	4,900,829	115	8,456,122
Sunbelt Total	108	5,265,499	139	9,350,032
U.S. Total	264	11,575,829	303	18,465,399

bbl/cd = barrel(s) per calendar-day. Calendar-day figures are the average volume a refinery unit processes each day, calculated as the actual total volume for the year divided by 365.

Source: API, 1971; Cantrell, 1981a, p. 112.

U.S. production. As with petroleum, Louisiana and Texas are the main producing states. In 1979, these two states produced 70 percent of the U.S. natural gas; with the addition of the output from New Mexico and Oklahoma, 85 percent of the U.S. production was accounted for by these four states.

Production is projected to decline slightly due to the maturing of the southern gas fields. However, this could change dramatically with the use of enhanced recovery techniques and with production from previously unexplored areas and from unconventional natural gas resources. The Gulf Coast area of Alabama, Florida and Mississippi, the Eastern Overthrust Belt, the Deep Anadarko in Oklahoma, and the Tuscaloosa Trend in Louisiana all have the potential to significantly increase the production of natural gas in the Sunbelt (SSEB, 1981).

With respect to future petroleum and natural gas production, DOE projections (U.S., DOE, EIA, 1980a) indicate a continuing decline in production from the Sunbelt. Due to the way in which the DOE data are aggregated, it is not possible to get a complete picture of future Sunbelt production. While most of the major producing areas are included in Table 6-7, some significant omissions should be kept in mind. Most notably, future production from all of Oklahoma, western New Mexico, and the Texas panhandle is not included, and the data for New Mexico only pertains to the southeast portion of the state. Nevertheless, the projected decline in production between 1985 and 1995 is evident throughout the areas included. An exception to the general decline in production is a projection that indicates that Oklahoma's average daily rate of crude oil production should increase to 531,000 barrels in 1985, compared with about 430,000 barrels per day (bbl/d) in 1981 (Vandewater, 1982). If this is added to the data provided in Table 6-7, the portion of the Sunbelt included is expected to account for approximately 1,435 MMbbl, 50 percent of the U.S. crude oil production, in 1985.

Although natural gas production also is expected to decline, even with some major producing areas omitted from Table 6-7, the South is projected to produce about 71 percent of the interstate natural gas in 1985. By 1995, production from the areas for which data were available is expected to decline to about 4.6 tcf and account for 55 percent of total U.S. production.

More complete data are available with respect to the future production of intrastate natural gas (Table 6-8). In 1985, the Sunbelt is projected to produce 5.5 tcf of gas, or 76 percent of the U.S. production used intrastate. Virtually all of the projected intrastate gas production in the Sunbelt will take place in Region 6. Overall, production in the Sunbelt is expected to drop slightly by 1990 but then remain stable to 1995.

B. Exploration and Development Activities

Major increases in wellhead prices have lead to unprecedented exploration and development activity. The number of new wells drilled since the mid-1970's has increased dramatically and current activity is the highest in 20 years. In 1980, 64,628 new wells were drilled, an increase of 74 percent over the number of wells drilled just 5 years earlier.[1] This surpasses a figure

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[1] This includes Alaska and offshore wells.

TABLE 6-7: FUTURE PRODUCTION OF PETROLEUM AND INTERSTATE GAS

	Petroleum											
	Crude Oil (million barrels)			Other[a] (million barrels)			Total (million barrels)			Natural Gas (billion cubic feet)		
Region	1985	1990	1995	1985	1990	1995	1985	1990	1995	1985	1990	1995
W. Texas/ E. New Mexico	531	410	366	30	21	15	561	431	381	269	301	312
W. Gulf Basin	555	481	401	127	91	70	682	572	475	743	653	625
Gulf of Mexico	192	184	189	86	66	52	278	250	241	1,392	1,008	725
Total[b]	1,278	1,075	960	243	178	137	1,521	1,253	1,097	2,404	1,962	1,662
U.S. Total	2,932	2,998	3,278	312	240	206	3,244	3,238	3,484	3,375	3,165	3,020

Source: U.S., DOE, EIA, 1980a.

[a] Includes butane, gas liquids, naphtha, and other petroleum products. This does not include production for intrastate use which accounts for 6 percent of the total U.S. petroleum production in 1985, 8 percent in 1990 and 10 percent in 1995.

[b] This is not the total for the entire Sunbelt due to the aggregations used by DOE when making their projections. The most notable omissions from this table are western New Mexico and all of Oklahoma and the Texas panhandle.

TABLE 6-8: INTRASTATE GAS PRODUCTION PROJECTIONS
(billion cubic feet per year)

	1985	1990	1995
Region 4	111	113	129
Region 6	5,438	4,756	4,734
Sunbelt Total	5,549	4,869	4,863
U.S. Total	7,277	6,811	6,740

Source: U.S., DOE, EIA, 1980a.

which had stood since 1956, when 58,160 wells were drilled (McCaslin, 1981a).

Based on a survey of plans of U.S. operators, the industry is projected to drill 77,264 wells in 1981 (Table 6-9). During 1980, oil wells accounted for almost two-thirds of the well completions and this pattern is expected to continue in 1981. Drilling for gas, which suffers from relatively lower prices and surplus productive capacity, is rising, but at a more modest rate (McCaslin, 1981a).

The Sunbelt accounts for a large portion of the drilling activity in the U.S. In 1981, 45,979 (60 percent) of the wells drilled are projected to be in the South. Of these wells, 39,402 or 86 percent, are expected to be drilled in Texas, Oklahoma, and Louisiana. Almost 80 percent of the 1981 drilling in the South is targeted for development wells. This activity is directed toward holding or increasing current production capacity but only occasionally adds significantly to proved reserves via positive revisions or discovery of new reservoirs in old fields. Exploratory drilling, aimed at adding to reserves, is expected to account for 9,519 of the 1981 wells drilled in the Sunbelt, and almost 60 percent of these wells are projected for Texas.

Although exploratory drilling accounts for a relatively small portion of the total drilling activity, some significant activity is taking place in the Sunbelt. For example, nearly 20 percent of the rigs working in the U.S. today are located in the Anadarko Basin, which stretches across southwestern Kansas, western Oklahoma and the northern half of the Texas Panhandle (McCaslin,

TABLE 6-9: WELL DRILLING ACTIVITY

	1970			1975			1981 (Forecast)		
	Total Wells[a]	Explor-atory	Devel-opment	Total Wells[a]	Explor-atory	Devel-opment	Total Wells[a]	Explor-atory	Devel-opment
Region 4									
Alabama	45	27	18	110	65	45	275	115	160
Florida	25	10	15	46	27	19	30	18	12
Georgia	4	4	-	3	3	-	2	2	-
Kentucky	809	228	581	918	313	605	1,530	500	1,030
Mississippi	556	235	321	451	263	188	860	400	460
Tennessee	50	22	28	203	143	60	380	200	180
Total	1,489	526	963	1,728	811	917	3,077	1,235	1,842
Region 6									
Arkansas	307	85	222	321	78	243	890	190	700
Louisiana[b]	2,948	671	2,277	3,036	708	2,328	6,135	1,335	4,800
New Mexico	728	163	565	1,213	170	1,043	2,610	445	2,165
Oklahoma	2,685	458	2,227	3,646	394	3,252	10,100	800	9,300
Texas[b]	7,722	2,098	5,624	12,086	3,203	8,883	23,167	5,514	17,653
Total	14,390	3,475	10,915	20,302	4,553	15,749	42,902	8,284	34,618
Sunbelt Total	15,879	4,001	11,878	22,030	5,364	16,666	45,979	9,519	36,460
U.S. Total	28,120	7,693	20,427	37,235	9,214	28,021	77,264	16,768	60,478

Sources: API, 1978 and updates; McCaslin, 1981a.

[a] Excludes service wells, stratigraphic and core tests.

[b] Includes offshore.

1981b). Many of the wells, and all of the deep holes, in Oklahoma will be drilled in the Anadarko. Exploratory drilling results were excellent for 1980; in a four county area in western Oklahoma there were 17 new field discoveries and 16 new zone strikes and/or major extensions. Overall, the Anadarko ranked third among the geologic provinces with respect to the number of new field wildcats completed with 425, and ranked fifth in total completions with 4,397.

Alabama also has experienced an upsurge in oil and gas activities in recent years. State figures show that there were 23 producing oil and gas fields in Alabama in 1971; by the beginning of 1981, the number of fields had increased to 102. The 16 new fields found in 1980 topped the previous high of 12 found in 1979. Of the 28 new fields established over the past two years, 21 are located in the Black Warrior Basin in northwestern Alabama. The remainder are in the Salt Basin in the southwestern part of the state (McCaslin, 1981c).

The nation's oldest oil province is on the brink of major exploratory activity. In the Eastern Overthrust Belt in the Appalachian Basin, leasing has been widespread, seismic crews are active and large exploratory programs are planned (McCaslin and Sumpter, 1981). Although only a few holes were drilled in 1980, over 20 tests were expected in or near the Eastern Overthrust Belt during 1981. In addition, 20 seismic crews are working along the belt and seismic exploration is expected to increase by 25 percent during 1981.

Based on the age of the rocks and the production found so far, the Eastern Overthrust Belt is expected to be a gas province, for the most part. However, geologists quickly add that it is much too early to rule out chances for oil discoveries and that finding the key to big production in the region may be at least five years away. Because of the size of the region and the abundance and diversity of structural settings, a large number of exploratory wells are likely to be drilled before the major deposits are found (McCaslin and Sumpter, 1981).

6.3.4 Environmental Issues

Table 6-10 presents selected environmental issues associated with the development of petroleum and natural gas. The basic exploration and drilling procedures utilized for petroleum and natural gas do not differ substantially. The greatest potential danger with this stage is the drilling procedure itself. A blowout, or uncontrolled flow of crude oil or gas, can occur when an oil or gas formation is breached. Although the number of drilling blowouts is relatively small, they can result in the release of large amounts of crude oil containing nondegradable organics that are potentially toxic (MITRE, 1981). In addition to direct land

TABLE 6-10: SELECTED ENVIRONMENTAL ISSUES FOR OIL AND GAS DEVELOPMENT

Production Stage	Water Quality	Air Quality	Land Use and Solid Waste	Safety and Health
Exploration and drilling	Aquifer contamination Oil spills Mud pit spills Salt water disposal	Air pollutants from fires	Surface disruption from roads and drilling sites Drilling mud disposal	Fires and accidents
Production	Oil spills Saltwater spills	Sour gas removal system emissions (H_2S and SO_2)	Hazardous waste disposal	Fires and accidents
Refining	Wastewater treatment Deep well injection	Hydrocarbons and other criteria pollutants	Local land disturbance	Long-term exposure to hydrocarbons for operators and the public Fires and accidents
Transportation and distribution	Spills	Hydrocarbon emissions	Rights-of-way Habitat fragmentation	Fires and accidents

H_2S = hydrogen sulfide

and water pollution, in the event of fire, air pollutants are released including hydrocarbons, nitrogen oxides (NO_x), SO_2, carbon monoxide (CO), and particulates.

Accidents occur more frequently in high-pressure natural gas operations than in corresponding crude oil operations; however, natural gas accidents generally cause less environmental damage. For example, water pollution resulting from gas well blowouts or gas pipeline leaks would be much less severe than from similar oil operations. One exception is the high concentration of hydrogen sulfide (H_2S) sometimes associated with natural gas.

The muds used during drilling are another source of potential environmental problems. It has been estimated that 1,200 to 2,500 barrels of mud are required for a well 8,500 to 11,500 feet deep (Wilkins, 1977). Unless disposed of properly, these muds can contaminate soils and surface and ground water supplies. For example, if the mud is spread on the ground, rainwater soaking through the soil and into the aquifers carries with it the toxic additives in the drilling mud, such as lime, caustic soda, chlorides, and arsenic. In Oklahoma, approximately 300 communities depend on ground water to meet all of their water needs and about 80 percent of the water used in irrigation comes from underground sources. Virtually all of the ground water to supply these communities and for irrigation is in the western half of the state, an area of increasingly heavy drilling activity (Fossett, 1981).

Upon reaching the surface, a considerable amount of brine (water containing sodium chloride and other salts) is separated from the crude oil--often as much as two to three volumes of brine for every volume of oil (Wilkins, 1977). Most of this brine is disposed of in underground formations or used for injection purposes during secondary recovery. Water sources can be contaminated through the fracturing and connection of underground aquifers and surface water can be polluted from accidental spills and leakages from holding ponds (Fairchild, Hall, and Canter, 1981).

Other environmental concerns during the drilling and production phases include noise and air emissions from drilling rigs and site preparation, soil erosion losses resulting from site access and preparation, possible sedimentation in nearby streams, oil spills, and land subsidence. Offshore activities could result in interference with fishing operations, water pollution from brine discharges released during drilling and production and from the disposal of drilling muds. Oil spills or chronic leakage around the drilling platform could result in serious localized impacts, particularly on bay and estuarine systems.

A potential source of air quality problems is the removal and disposition of H_2S, primarily associated with natural gas production. H_2S is a hazardous substance which must be removed before further processing. After removal, the free H_2S can be burned or sent to a sulfur recovery plant. If it is burned, there may be considerable amounts of SO_2 released to the atmosphere (Leggett and Williams, 1979).

These and other environmental concerns associated with the discovery and production of petroleum and natural gas resources will be heavily concentrated in the Sunbelt--an area experiencing unprecedented drilling activity. Further, since this activity is highly concentrated in a few states (Texas, Oklahoma, Louisiana) the potential cumulative impact of oil and gas development is much greater.

6.4 DIRECT USE OF COAL

6.4.1 Introduction

While the importance of oil and gas as major sources of energy will continue for the foreseeable future, reduced dependency can be facilitated by the development of alternative fuel sources. The rising prices of oil and natural gas and the comparative cost advantage of coal make it an attractive alternative energy source, particularly as a boiler fuel. It is the only source that can increase its absolute contribution quickly and economically. The Powerplant and Industrial Fuel Use Act (1978) is designed to increase the use of coal by prohibiting oil and gas as fuels in new power plants and large industrial heating units.

According to a ten year coal forecast issued by the National Coal Association (NCA) coal production is expected to increase from 800 million tons in 1980 to 1,300 million tons by 1990 (see Table 6-11). Utilities are expected to continue to be the largest user group in the United States and consume about 935 million tons in 1990. Increased demands from other sectors (e.g., synthetic fuels, industry, export) are projected to lead to significant growth in the coal industry. The Sunbelt--particularly Kentucky, Texas, and New Mexico, is expected to supply a substantial portion of that coal.

This section will discuss the availability of coal resources in the South, its production and use for electricity generation, and highlight the environmental issues associated with the production and use of coal.

6.4.2 Resource Distribution

Figure 6-2 shows the major coal basins of the coterminous United States. These coal deposits are widely dispersed and approximately 13 percent of the country has coal beneath the

TABLE 6-11: COAL PRODUCTION AND USE
(millions of tons)

	1975	1980	1985	1990
Production	655	830	Approx. 1,000	1,300[a]
End Use				
Utilities	403	565	727	935
Synthetic Fuels	---	---	4	38[b]
Industry	62	77	94.5	140.5
Export	67	70	105	142

Source: NCA, 1981, p. 391; Coal Age, 1981, p. 45.; U.S., Congress, OTA, 1979, p. 42.

[a] Estimated range from 1.1 to 1.6 billion.

[b] Synfuel producers are projected to use as little as 9 million tons or as much as 75 million tons, depending on how fast the synfuel industry develops.

surface. Within the Sunbelt, Kentucky, Tennessee, Alabama, Oklahoma, Texas and New Mexico are the principal sources of coal.

The coal obtained from the Appalachian Basin has supplied 60 percent or more of total annual national production since coal mining began in the United States. It generally is the highest grades of bituminous coal and is often high in sulfur content. The coal in the Illinois Basin (which includes western Kentucky) has a slightly lower heat content than Appalachian coal, and the sulfur content can be quite high. For the most part, the coal beds of Oklahoma and Arkansas are thin with some moderately thick seams occurring in the southern portion of Oklahoma. Both states have coal of metallurgical grade that is shipped out of the state. The lignite deposits in Texas and Louisiana and subbituminous beds in New Mexico are recoverable from surface mines. These coals have a substantially lower heat and sulfur content and a higher moisture content than eastern coal (U.S., Congress, OTA, 1979).

As of January 1, 1976, the United States had approximately 283 billion tons of coal reserves recoverable with existing mining

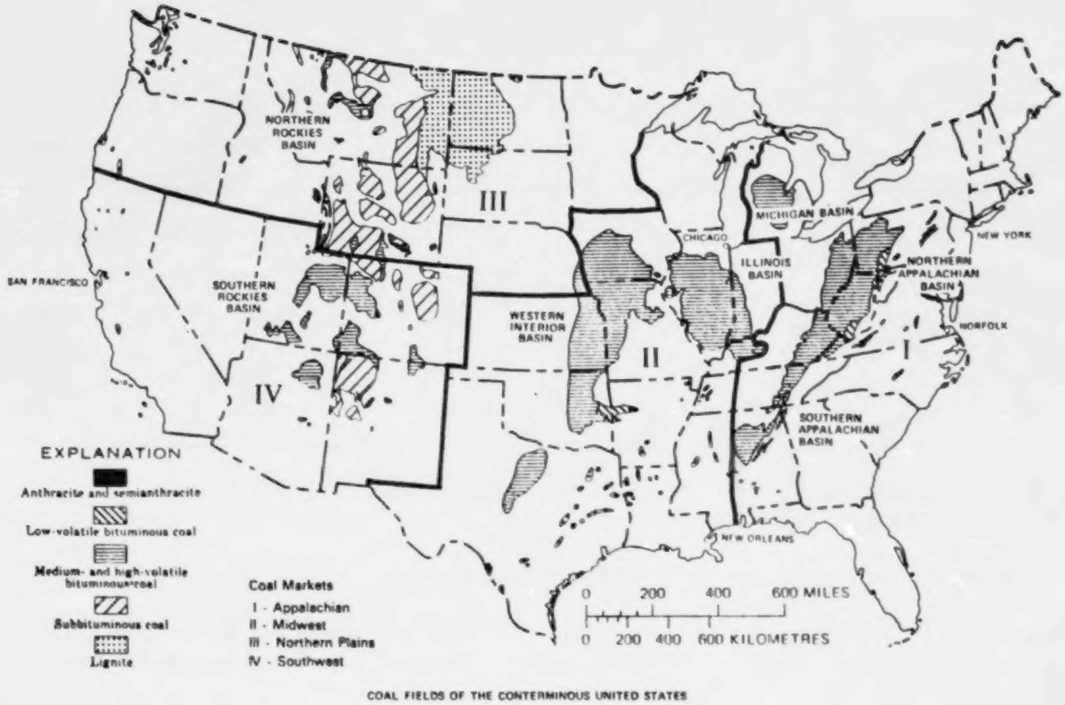

Figure 6-2: Coal Fields of the Coterminous United States

Source: U.S., Library of Congress, Congressional Research Service, 1980, p. 595.

technology (Table 6-12). The Sunbelt contained 26.5 billion tons of recoverable reserves, a little over 9 percent of the U.S. total reserves.

Within the South, Region 4 has 75 percent or 19.6 billion tons of the total recoverable reserves. Most (86 percent) of these reserves are located in the eastern and western coal fields of Kentucky. Together, Kentucky and Alabama account for 82 percent of the underground reserves and 60 percent of the reserves recoverable from surface mines in the Sunbelt.

Within Region 6, most of the reserves are recoverable through surface mining--almost 5 billion tons or about 70 percent of the region's total coal reserves. Texas does not have any recoverable underground reserves. Furthermore, while New Mexico, Oklahoma, and Arkansas do have some recoverable underground reserves, significant recovery of these reserves is considered questionable in

TABLE 6-12: RECOVERABLE COAL RESERVES AS OF JANUARY 1, 1976[a]

Region/State	Underground (Q's)	Surface (Q's)	Total Q's	Underground (millions of tons)	Surface (millions of tons)	Total (millions of tons)
Region 4						
Eastern Kentucky	136	84	220	5,200	3,600	8,800
Western Kentucky	118	69	187	4,800	3,200	8,000
Alabama	27	26	53	1,000	1,100	2,100
Tennessee	9	6	15	400	300	700
Total	290	185	475	11,400	8,200	19,600
Region 6						
New Mexico	29	42	71	1,200	2,000	3,200
Texas	--	52	52	--	2,500	2,500
Oklahoma	18	8	26	700	300	1,000
Arkansas	4	3	7	100	100	200
Total	51	105	156	2,000	4,900	6,900
Sunbelt Total	341	290	631	13,400	13,100	26,500
U.S. Total	3,931	2,307	6,238	169,000	113,900	282,900

Source: Adapted from U.S., Congress, OTA, 1979, p. 63.

[a] Recoverable reserves can be mined with existing technology and are deposits no deeper than 1,000 feet and at least 28 inches thick for underground mines, or with depth-to-seam thickness ratios of 10 or less for surface mines. These estimates are based on 57 percent recoverability in underground mines and 80 percent in surface mines.

New Mexico, and underground mining has ceased in Oklahoma and Arkansas.

At the end of 1979, producing coal mines reported a total of 25 billion tons of recoverable reserves (Table 6-13). About 6 billion tons of the recoverable reserves from these mines are located in the Sunbelt; Kentucky and New Mexico account for two-thirds of these reserves. Of the total estimated recoverable reserves in the South, only 22 percent are associated with currently producing mines. Except for Tennessee and New Mexico, which have substantial amounts of their estimated reserves located in existing mines, other states will need to open new mines to tap the remaining reserves. In 1979, Kentucky already had 1,351 mines which only accounted for approximately 14 percent of the total recoverable reserves. The 201 mines in Alabama contained 27 percent of the total recoverable reserves. The remaining states, particularly Oklahoma, Texas, and Arkansas, have few producing mines containing a small percentage of the total estimated recoverable reserves.

Although not likely, the estimates of recoverable reserves could be revised downward if more stringent regulations are enacted that would make recovery uneconomical. Upward revision could result if more recoverable resources are identified, new techniques increase the recoverable fraction, or if regulations and standards are changed to make recovery more economically attractive.

6.4.3 Current and Future Status

A. Coal Production

Table 6-14 presents the 1980 coal production levels (U.S., DOE, EIA, 1981d) and projections from the Office of Technology Assessment for 1985 and 2000 (U.S., Congresss, OTA, 1979). Overall, the proportion of U.S. production from the Sunbelt is projected to decrease slightly over the next 20 years, from 29 percent to 20 percent between 1980 and 2000. However, in terms of absolute tonnage produced, output from the Sunbelt is projected to increase by 65 percent--from 240 million tons in 1980 to 396 million tons in 2000.

Within Region 4, production from surface mining is expected to decrease between 1980 and 2000 while coal from underground mining is projected to increase substantially. Overall, production from Region 4 is projected to increase from 187 million tons to 230 million tons. Region 6 is not expected to have any significant amount of underground mining, however, the production of coal from surface mines is projected to increase between 1980 and 2000. In 1980, Texas, New Mexico, and Oklahoma produced about 52 million tons of surface mined coal and accounted for 36 percent of the total surface production in the Sunbelt. By 2000 these states are

TABLE 6-13: RECOVERABLE COAL RESERVES FROM PRODUCING MINES, 1979[a]
(millions of tons)

Region/State	Underground Reserves	Surface Reserves	Total Recoverable Reserves	% of Total Recoverable Reserves in Producing Mines
Region 4				
Eastern Kentucky	1,235	555	1,790	20
Western Kentucky	494	148	642	8
Alabama	353	211	564	27
Tennessee	462	48	510	73
Total	2,544	962	3,506	18
Region 6				
New Mexico	w	w	1,368	43
Texas	---	785	785	31
Oklahoma	---	49	49	5
Arkansas	---	2	2	1
Total	---	---	2,204	32
Sunbelt Total	---	---	5,710	22
U.S. Total	11,736	13,427	25,163	9

w = withheld to avoid disclosure of individual company data.

Source: Adapted from U.S., DOE, EIA, 1981c.

[a] Excludes mines producing less than 10,000 tons of coal per year.

TABLE 6-14: COAL PRODUCTION: CURRENT AND PROJECTED[a]
(millions of tons per year)

Region/State	Surface			Underground			Total		
	1980	1985	2000	1980	1985	2000	1980	1985	2000
Region 4									
Eastern Kentucky	49.6	36	40	59.6	50	85	109.2	86	125
Western Kentucky	21.4	21	28	19.6	20	33	41.0	41	61
Alabama	16.9	12	10	9.5	15	27	26.4	27	37
Tennessee	4.8	4	3	5.1	3	4	9.9	7	7
Total	92.7	73	81	93.9	88	149	186.5	161	230
Region 6									
New Mexico	17.5	38	75	1.0	--	2	18.5	38	77
Texas	29.4	43	85	---	--	--	29.4	43	85
Oklahoma	5.4	3	2	---	1	2	5.4	4	4
Total	52.3	84	162	1.0	1	4	53.3	85	166
Sunbelt Total	145.0	157	243	94.8	89	153	239.8	246	396
U.S Total	492.2	260	925	337.5	335	580	829.7	955	1,505

Source: Compiled from U.S., Congress, OTA, 1979, p. 48, and U.S., DOE, EIA, 1981d, p. 5.

[a] The projections assume a 100 Q energy demand by the year 2000.

expected to increase surface mine production to 162 million tons, 67 percent of the Sunbelt's surface mine production.

These projections are only estimates of what could happen with coal production in the Sunbelt. The actual production levels and the distribution of that production could be influenced by many factors: overall energy demand patterns, developments in the nuclear power industry, changes in the cost of production and transportation of coal, the development of better and cheaper technologies for the control of emissions from high-sulfur coal, changes in regulatory standards, and customers' perceptions of the reliability of delivered supply. These and other unpredictable factors could produce interregional shifts of several hundred million tons annually by 2000 (U.S., Congress, OTA, 1979).

B. The Use of Coal for Electricity Generation

About 70 percent of the coal mined in the United States is consumed by utility companies to generate electricity. Electric utilities are expected to consume about the same percentage of coal for the next ten years, however the percentage of electrical power generated using coal is projected to increase from 48 percent in 1979 to 52 percent in 1985 and 57 percent by 1990 (National Coal Association, 1981).

In 1977, the Sunbelt accounted for 33 percent (67,517 megawatts [MW]) of the total U.S. electric generating capacity from coal. Within the Sunbelt, 86 percent of the coal-fired electric generating capacity was located in Region 4. Nationally, 245 new coal-fired units are scheduled to come online from 1979 through 1988. These units have a total generating capacity of 127,568 MW (Table 6-15). Forty-four percent of these new units and 50 percent of the additional generating capacity is projected to be located in the South. Of the 109 coal-fired units scheduled for operation in the South, the number of units and the total generating capacity (63,428 MW) are almost equally divided between Regions 4 and 6. Overall, the proportion of the South's total electric generating capacity accounted for by coal is expected to remain about the same from 1977 to 1990 (approximately 43 percent). However, within Region 4, coal's share of electric capacity is projected to decrease from 65 percent in 1977 to 50 percent in 1990 (Honea, Hillsman and Mader, 1979). This is due in large part to projected increases in nuclear power, particularly in the Tennessee Valley Authority area and in the Carolinas. However, given current constraints, it is not clear just how much capacity nuclear power will contribute over the next 10 years (see Section 6.6). Even though coal's share of generating capacity is projected to decline, 30,777 MW of new coal-fired capacity is, nevertheless, scheduled for Region 4. For example, Florida, which is heavily dependent on oil, and Kentucky are scheduled to add substantially to their current coal-fired capacity.

TABLE 6-15: ELECTRICITY GENERATING CAPACITY FROM COAL STEAM

State	1977 Capacity (MW)	New Coal Units Scheduled 1979-1988 Number of Units	New Coal Units Scheduled 1979-1988 Capacity (MW)
Region 4			
Alabama	8,658	5	2,596
Florida	3,237	13	8,076
Georgia	8.416	4	2,629
Kentucky	11,838	18	10,806
Mississippi	2,662	1	1,600
North Carolina	10,403	3	2,160
South Carolina	3,502	7	2,910
Tennessee	9,241	---	---
Total	57,957	51	30,777
Region 6			
Arkansas	126	4	2,880
Louisiana	820	11	6,240
New Mexico	2,818	4	1,642
Oklahoma	515	10	4,855
Texas	5,281	29	17,034
Total	9,560	58	32,651
Sunbelt Total	67,517	109	63,428
U.S. Total	205,945	245	127,568

Source: Honea, et al., 1979, p. 89; and U.S., DOE, FERC, 1981, p. 9.

The situation in Region 6 is very different. Except for New Mexico, the states in the Southwest are very dependent on oil- and gas-fired units for electricity generation. In 1977, only 14 percent of the total electric capacity was provided by facilities that burned coal. New Mexico is the only state in the region that is not projected to experience a large increase in coal-fired capacity between 1979 and 1988 (U.S., DOE, FERC, 1981). In total, Region 6 is expected to bring online 32,651 MW of new capacity during this period.

In 1980, the Sunbelt consumed approximately 200 million tons of coal for electricity generation; a large percentage of this coal, 127 million tons, was burned in Region 4 (Table 6-16). During the next 10 years, only a small amount of the existing coal-fired capacity is expected to be retired (U.S., DOE, EIA, 1980c).

Consequently, the demand for coal to supply these units will continue. In addition, by 1988, the total annual demand for coal to supply scheduled new units in the Sunbelt is expected to reach 249 million tons. Not only will both regions be burning sutstantially more coal for electricity generation in 1988, but most of the coal supply will be mined within the Sunbelt. Sources for approximately 94 percent of the new coal demands in Region 6 have been identified and of these, about two-thirds are within the region. Within Region 4, even less coal will be supplied from mines outside the region. Thus, the Sunbelt is expected to experience a substantial increase in the amount of coal burned for electricity generation and in the production of coal to supply exisitng and scheduled new power plants.

6.4.4 Environmental Issues

A variety of environmental issues are associated with the projected increases in coal production and consumption in the Sunbelt, as summarized in Table 6-17. Generally, the impacts associated with mining are located around the area of production. For example, the potential problems of surface mining are related to land modification leading to possible water and wind erosion, the modification of topsoil, temporary or permanent changes to vegetation, potential contamination of soil and water from the weathering of toxic strata, and the impairment of wildlife habitats. The land also is removed from other uses (e.g., agriculture, recreation) until reclamation operations are complete. Surface mining can impact ground water supplies by (1) drainage of usable water from shallow aquifers; (2) lowering of water levels in adjacent areas and changes in flow directions; and (3) contamination from mine leakage (U.S., DOE, Asst. Sec. for Environment, Off. of Technology Impacts, 1980, p. 5-104). In addition, runoff from surface mines can cause sedimentation problems in local streams.

Acid mine drainage and subsidence are the major problems resulting from underground mining. Acid drainage already is a major problem in the Kentucky coal fields, particularly from inactive mines. Some mining situations do not allow adequate permanent control once active mining and water treatment cease. A significant percentage of the underground mines that are active at present, or that will be opened in order to meet increased demands, could present acid drainage problems when they are closed (U.S., Congress, OTA, 1979). While regulations exist that attempt to control acid mine drainage, enforcement, especially with smaller mines, has been a long-standing problem.

Both surface and underground mining operations generate problems from waste materials left at the surface in piles or spoil banks. These materials are subject to runoff and erosion and can be the source of pollution of local streams and aquifers.

TABLE 6-16: ANNUAL COAL REQUIREMENTS FOR ELECTRIC UTILITIES

Region/State	Coal Consumed by Electric Utilities in 1980 (thousands of tons)	Coal Demand by New Units in 1988[a] (thousands of tons)
Region 4		
Alabama	18,383	5,824
Florida	6,980	17,701
Georgia	19,530	5,481
Kentucky	24,963	24,806
Mississippi	3,568	1,600
North Carolina	22,953	3,800
South Carolina	7,411	8,094
Tennessee	23,295	----
Total	127,083	67,306
Region 6		
Arkansas	3,389	10,000
Louisiana	2,823	23,905
New Mexico	10,980	6,740
Oklahoma	8,002	16,500
Texas	47,647	124,277
Total	72,841	181,422
Sunbelt Total	199,924	248,728
U.S. Total	565,000	396,160

Source: U.S., DOE, EIA, 1981e, p. 21; and U.S., DOE, FERC, 1981, p. 9.

[a] This tonnage represents a 12 month demand for units due onstream between 1979 and 1987, and a prorated demand for units scheduled for operation during 1988.

TABLE 6-17: SELECTED ENVIRONMENTAL ISSUES IN THE PRODUCTION AND DIRECT USE OF COAL

Production Stage	Land Use and Water Quality	Air Quality	Ecosystems	Safety and Health	Other
Mining and upgrading	Short- and long-term land use changes, erosion, and uncertainty of reclamation in the arid Southwest (New Mexico) Aquifer disturbance and pollution; leaching from waste piles Nonpoint source water pollution (acid mine drainage--Southeast; sedimentation--New Mexico) Subsidence	Fugitive dust (especially in New Mexico) Mine fires Waste pile fires	Disruption of wildlife habitat and changed productivity of the land Siltation of streams Habitat fragmentation from primary and secondary population growth	Mining accidents Occupational diseases in underground coal mining (e.g., black lung)	Increased water use for reclamation Transportation impacts on road traffic and noise
Conversion (steam electric plants)	Potential surface and groundwater pollution from holding ponds Thermal wastewater discharges Disposal of large amounts of solid wastes Local land-use changes Construction on flood plains	Emissions of "criteria pollutants" (i.e., NO_x, SO_2, particulates, etc.) Possible releases of trace elements	Air pollution damage to plants Contributions to acid rain Wildlife habitat fragmentation from construction population increases Contributions to the "greenhouse" effect	Fire and accidents	Water availability issues (especially in western Sunbelt)
Transport	Land use changes from rights-of-way		Disruption of wildlife habitat	Uncertain effects of high voltage transmission lines	

Air quality problems from mining usually are local in nature and are related to fugitive dust from mining operations, storage piles, and coal hauling. Spontaneous combustion in piles of waste materials is common in Appalachia; these fires produce noxious fumes that may have adverse health impacts (U.S., Congress, OTA, 1979).

Mining operations have a definite impact on the health and safety of the workers. In 1977, 139 coal workers were killed and about 15,000 suffered a disabling injury. If coal production triples, it could result in about 370 deaths and 42,000 disabling injuries per year (U.S., Congress, OTA, 1979).

Black lung disease, the nonclinical name for a variety of respiratory illnesses of which coal workers' pneumoconiosis (CWP) is the most prominent, is the major mine-worker health issue. Federal respirable dust standards could help lower the prevalence of CWP but thousands of workers nevertheless will be disabled by various respiratory diseases. Under the most optimistic assumptions, it is estimated that between 11,000 and 18,000 currently active miners will show X-ray evidence of CWP in the year 2000 and at least an equal number will exhibit other respiratory problems.

Even with the use of control technologies, the burning of coal can release substantial quantities of sulfur, nitrogen, carbon oxides, and particulate matter, and small amounts of trace elements and polynuclear aromatic hydrocarbons. For example, in 1978, air emissions from coal-fired power plants in Kentucky contained 1.5 million tons of sulfur oxides (SO_x) and accounted for 94 percent of the total SO_x emissions in the state (U.S., EPA, Off. of Air Quality Planning and Standards, 1980). In addition, these power plants emitted 345 thousand tons of NO_x (56.8 percent of the state's total) and 96 thousand tons of particulates (15 percent of the total). While emissions levels in Texas were not nearly as high, neither was the level of coal consumption. Coal-fired plants in Texas emitted 312 thousand tons of SO_x and 173 thousand tons of NO_x. However, between 1979 and 1988, Texas is scheduled to add 29 coal-fired units that would burn 124 million tons of coal a year, in addition to the 47 million tons currently consumed by existing plants.

SO_2 and nitrogen dioxide (NO_2) are subject to chemical transformation once in the atmosphere and are believed to be a major contributor to acid precipitation. Sulfur and nitrogen oxides have their own individual environmental effects as well. Locally deposited SO_2 can damage crops and forests when meteorological or geographical conditions cause the plume to impact the terrain.

The use of precipitators can remove large particulate matter from emissions with a great deal of efficiency. However, precipitators are not as efficient in removing fine particulates and the associated trace elements and hydrocarbons that are absorbed on their surfaces. The potential for human health impact is based on the ability of fine particulates to penetrate the lung's defenses where the toxic materials on the particles could then affect tissues.

The general problems of air pollution from coal combustion are exacerbated by the fact that areas can experience poor air quality caused by sources outside their jurisdictional boundaries (U.S., Congress, OTA, 1979). The increased use of lignite in power plants in Texas and Louisiana will increase air emissions. The area of lignite development and use (primarily in eastern Texas) is aligned with the prevailing winds from the southwest to the northeast. Emissions from the increased combustion of coal in Region 6 could have negative impacts (e.g., increased acid precipitation) on the southeast and northeast sections of the country.

The major problems of burning coal with respect to land and water stem from the secondary effects of environmental controls. These include the effects of cooling tower blowdown, water consumption, and waste products collected by air pollution controls. Although the Clean Water Act (1977) regulates effluents, the increase in coal burning capacity could lead to substantial increases in the discharge of dissolved solids in Florida, Louisiana, Oklahoma, and Texas, where large increases in coal-fired capacity are scheduled (U.S., Congress, OTA, 1979). Large quantities of wastes are generated by the particulate control devices and SO_2 scrubbers which can cause land use problems and environmental damage unless properly managed.

Thus, the increased production and consumption of coal in the Sunbelt could lead to problems related to land reclamation, air quality and water quality in these states projected to experience large increases in production and/or use. In addition, long-range transport of air emissions from the Southwest could exacerbate the acid precipitation problems that already exist in the East.

6.5 SYNTHETIC FUELS FROM COAL AND OIL SHALE

6.5.1 Introduction

Because of the continuing rise of oil and natural gas prices, coal and oil shale are being considered as alternative sources of gaseous and liquid fuel. Progress toward the development of the synfuels industry will be slow and it is not likely that the 1980 Energy Security Act (P.L. 96-294) goals of 500,000 bbl/d of oil from synfuels by 1987 and the equivalent of two MMbbl/d by 1992 will be met. However, synthetic gas and liquids derived from coal and oil shale are expected to be produced on a commercial scale in the next 5 to 10 years (Taylor and Moon, 1981).

Parts of the Sunbelt are likely to be involved in supplying feedstock for synfuel production as well as in the conversion of the feedstock into fuel. This section will discuss the availability of the natural resources required (coal, oil shale, water), the current and future status of synfuel production in the South, and the environmental issues associated with synthetic fuels.

6.5.2 Resource Availability

A. Coal

The Oak Ridge National Laboratory used a panel of experts to generate a set of criteria for siting facilities for the conversion of coal into synthetic fuels (Berry et al., 1978). Among the most important factors was the proximity of required natural resources--high-sulfur coal and water. Depending on the process used (Table 6-18) a synfuel plant designed to produce 50,000 barrels per day oil equivalent (bpdoe) would require between 20,000 and 40,000 tons per day (tpd) of coal (U.S., DOE, Asst. Sec. for Environment, Off. of Technology Impacts, 1980). Assuming normal mining and operating conditions, each plant would need 6 to 12 million tons of coal reserves yearly.

According to a study by the U.S. Geological Survey (USGS), all or portions of three of the coal regions most likely to be used for synfuel production are located within the study area--the Southern Appalachian region (eastern Kentucky and portions of Tennessee and Alabama), the Eastern region (western Kentucky), and the San Juan River region (northwestern New Mexico) (Rickert, Ulman and Hampton, 1979). Each of these areas has sufficient coal resources to supply several synfuel facilities. However, much of the coal in these regions already has been committed to utilities or to the steel industry. Further, in several coal regions, the beds are valuable aquifers, and the siting of synfuel facilities could be constrained by possible impacts on water supply and quality due to removal of the coal.

As noted previously, the proximity and availability of water is an important consideration when siting a synfuel plant. Like coal, the amount of water required for the synthetic fuel plant varies with the conversion technology selected. In general, based on an energy output of 50,000 bpdoe, coal liquefaction requires less water than gasification. In addition, the composition of the coal, cooling methods, and the product gas heating value are key factors affecting water requirements (Rickert, Ulman, and Hampton, 1979). High sulfur content coal, wet cooling processes and high-Btu product gas all increase the amount of water required.

TABLE 6-18: RESOURCE REQUIREMENTS ASSOCIATED WITH SYNFUEL CONVERSION TECHNOLOGIES, BASED ON PRELIMINARY DESIGN STUDIES
(normalized to 50,000 bbl/d crude oil equiv.)

Process	Input (tpd)	Conversion Thermal Efficiency (%)	Water[a] Requirements (AFY)
Oil Shale (surface)	125,000 (25 gal/ton shale)	65-70	6,000-10,000
Fischer-Tropsch (indirect liquefaction)	31,000 (Subbituminous 8,500 Btu/lb) 0.45% sulfur	56-60	11,000-12,000
EDS (direct liquefaction)	20,000 (Bituminous 12,663 Btu/lb) 4% sulfur	60-64	7,500-8,500
SRC (direct liquefaction)	21,000 (Bituminous 12,518 Btu/lb) 3.5% sulfur	58-62	5,500-6,500
Mobil Technology Coal-to-Methanol-to-Gasoline	31,000 (Subbituminous 8,500 Btu/lb) 0.45% sulfur	56-58	11,000-12,000
Lurgi dry ash (high Btu coal gasification, 250 MMscf/d)	38,000 (Lignite 6,783 Btu/lb) 0.6% sulfur	58-60	20,000

tpd = tons per day
AFY = acre-feet per year
MMscf/d = million standard cubic feet per day

Source: Adapted from U.S., DOE, Asst. Sec. for Environment, Off. of Technology Impacts, 1980, p. 3-23.

[a] The actual water requirements for a specific site can be substantially reduced through maximum use of dry cooling.

The availability of water resources for synfuel development is affected by: (1) the extent of existing water appropriation; (2) the willingness of existing users to sell their water rights; (3) legislative, judicial and administrative decisions regarding the transfer of water rights; and (4) uncertainties about instream flow requirements for other uses. Based on assessments of surface and ground water resources, existing interstate compacts, and an assumed water transportation radius of 50 miles, the USGS (Rickert, Ulman, and Hampton, 1979) has delineated areas with sufficient unappropriated water for synfuel development. Of those areas within the southern regions that have the potential for synfuel production, only a portion of New Mexico appears physically to lack sufficient local water under present conditions. However, many would argue that this is not a constraint since water can be purchased by energy companies from other existing water users--especially agriculture.

B. Oil Shale

Much of the Eastern Devonian oil shale contains more natural gas but less oil per unit volume of rock than the western shales. Current surveys indicate that large sections of the eastern United States are underlain with Devonian shale with a great deal of the resource located in outcrop areas that are easily accessible to mining (Figure 6-3). The United States Geological Survey estimates that there may be between 400 billion and one trillion barrels of oil that could be extracted from Devonian shale (Shale Country, 1981).

A field survey to define the extent of eastern Devonian oil shale resources and their suitability as feedstock for the HYTORT process identified 423 billion barrels of recoverable oil resources in a three-basin area (IGT, 1980). A summary of the identified recoverable resources as of November 1979 is presented in Table 6-19. Fifty-six percent of the sources are located in Region 4 with an estimated 190 billion barrels of oil recoverable from shale deposits in Kentucky alone. Using HYTORT, a commercial plant producing 50,000 bbl/d of oil for 20 years would require about 3,000 acres of land (five square miles) based on the average yield for the three-basin area.

Not only is mining expected to be easier in the East than in the West, but the water for processing also is more plentiful. The water required for cooling methods used with oil shale conversion is similar to the amount used for coal gasification. Approximately 50 percent of the water consumed in aboveground oil shale production is used for spent shale disposal.

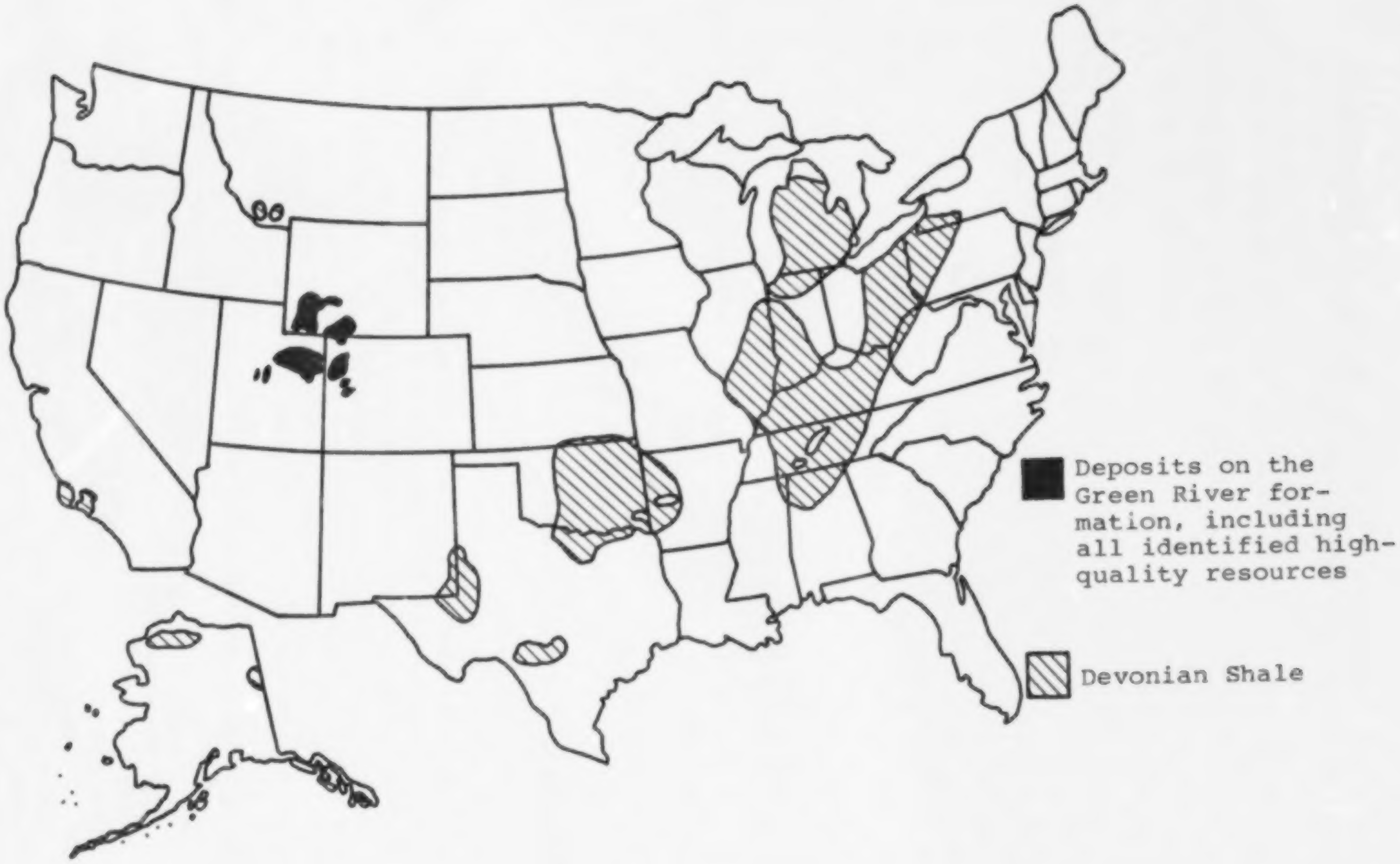
■ Deposits on the Green River formation, including all identified high-quality resources
▨ Devonian Shale

Figure 6-3: Distribution of U.S. Oil Shale Resources

Source: Duncan and Swanson, 1965.

TABLE 6-19: DEVONIAN OIL SHALE RESOURCES RECOVERABLE BY IGT HYTORT PROCESS

	Appalachian, Illinois, and Michigan Basin Areas		
	Total Area Suitable For Surface Mining	Resources Recoverable by Aboveground Hydroretorting	
State	sq. miles	billion bbl	thousands of bbl/acre
Ohio	980	140	222
Kentucky	2,650	190	112
Tennessee	1,540	44	44
Indiana	600	40	104
Michigan	160	5	49
Alabama	300	4	21
Total or Average	6,230	423	106

Source: IGT, 1980.

6.5.3 Current and Future Status

A. Coal

Figure 6-4 maps the possible locations of coal gasification and liquefaction projects in the Sunbelt. The distribution of projects between the two regions is relatively even, 18 in Region 4 and 15 in Region 6. However, 52 percent of the projects in the Sunbelt are concentrated in Kentucky (9) and along the Texas/Louisiana Gulf Coast (8). Eastern Tennessee, northern Alabama, and northwestern New Mexico also have multiple sites.

Summary information about each of the facilities on the map is presented in Table 6-20. Many of the projects are in the feasibility study phase, and as such, complete information is not available. In general, the low-Btu gas products will be used on site for either process heat, combined-cycle electricity generation, or kiln firing. High-Btu gas will be used as a direct substitute for natural gas in pipelines, chemical feedstocks, or as feed to a liquefaction process. Some high-Btu gas also will be used for electricity generation. Coal liquids will be used as a substitute for boiler fuel oils, and to produce transportation

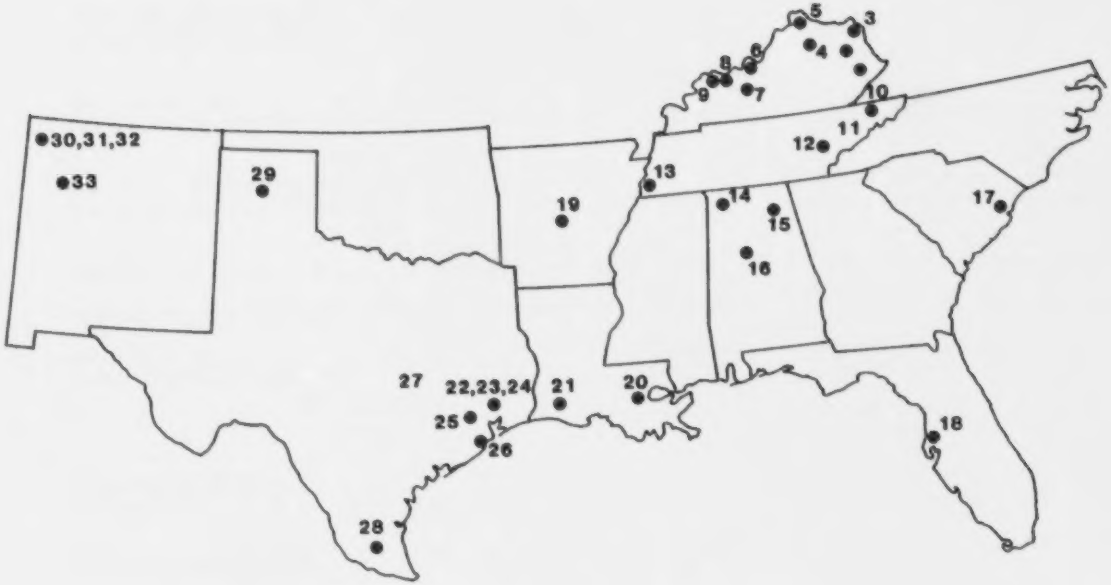

Figure 6-4: Coal Gasification and Liquefaction Projects (see Table 6-20 for descriptions of sites)

TABLE 6-20: COAL GASIFICATION AND LIQUEFACTION PROJECTS

Region/State	Sponsor	Status	Process	Input	Output
REGION 4					
Kentucky					
1. Pikeville	Pike County; Ky., DOE; Appalachian Regional Comm.; DOE	Complete 1981	Wellam-Galusha	3 tons/hr. low sulfur	60 x 10^6 LBG/hr.
2. Hitchins	General Refractories Co; DOE	-----[a]	Woodall-Duckman	2 tons/hr. low sulfur	895 x 10^6 LBG/d
3. Cattletsburg	Ashland oil; Hydrocarbon Research	Pilot in June 1980; Commercial by 1990	H-coal	Pilot, 600 tpd; Demonstration, 6,000 tpd; Commercial 20,000 tpd	50,000 bbl/d fuel oil or syncrude from commercial unit
4. Georgetown	Irwin Industrial Development Co.; DOE	-----	Wellam-Galusha	1.5 tons/hr. Eastern Kentucky	---
5. Florence	General Refractories Co.	9 month feasibility	Low-Btu	---	1,034 bpdoe
6. Breckenridge	Ashland Oil; Airco; DOE	Construction in 1983; operation in 1987	H-coal	High sulfur	50,000 bbl/d
7. Newman	Air Products and Chemicals; Southern; Wheelabrator-Frye	Proposed, future doubtful	SRC-I	6,000 tpd, high sulfur Kentucky	20,000 bbl/d possible expansion to 100,000 bbl/d
8. Baskett	Lurgi; Badger Energy; W.P. Grace; DOE	Preliminary design, onstream 1986	Texaco and Mobil Methanation	29,000 tpd, high sulfur Eastern	50,000 bbl/d gasoline
9. Henderson	Texas Eastern Synfuels; Texas Gas Transmission	Feasibility study, construction proposed	Fischer-Tropsch	28,000 tpd	145 x 10^6 cfd HBG, chemicals, and transportation fuels; equivalent to 50,000 bbl/d

(continued)

TABLE 6-20: (continued)

Region/State	Sponsor	Status	Process	Input	Output
REGION 4 (continued)					
Tennessee					
10. Kingsport	Tennessee Eastman	Onstream late 1983	Texaco Gasification, Indirect Liquefaction	1,600 tpd	---
11. East Tennessee	Tennessee Energy Inst.	Possible construction 1983	---	---	3.6 x 10^6 bbl/yr.
12. Oak Ridge	Tennessee Synfuels Assoc. (Cities Service and Koppers)	Onstream 1985-86	Kellogg/ Mobil-M	5,480 tpd	9,000 bbl/d gasoline; 1,500 bbl/d LBG; 550 tpd sulfur
13. Memphis	Memphis Light, Gas, and Water; Foster Wheeler; Delta Refinery; DOE; IGT	Preliminary work completed; onstream by 1986	IGT-U GAS	3,100 tpd, Kentucky #9, high sulfur	154 x 10^6 cfd MBG
Alabama					
14. Muscle Shoals	Tennessee Valley Authority (TVA)	Onstream mid-1980	Texaco	200 tpd	135 tpd ammonia
15. Murphy Hill	TVA; Bechtel National; C.F. Braun; Foster Wheeler	First module onstream by 1985; last by 1987	Koppers-Totzek	20,000 tpd	350 x 10^6 cfd MBG, and liquid products; 50,000 bpdoe
16. Wilsonville	Southern Company Services; DOE; EPRI	Operational	SRC-PAMCO	6 tpd	---
South Carolina					
17. Georgetown	Micrex Corporation	9 month feasibility	---	---	4,310 bpdoe MBG
Florida					
18. Pinellas County	Florida Power	12 month feasibility	Combined cycle	---	7,458 bpdoe MBG; electric power

(continued)

TABLE 6-20: (continued)

Region/State	Sponsor	Status	Process	Input	Output
REGION 6					
Arkansas					
19. Redfield	Arkansas Power and Light	Feasibility study requested	Texaco	Illinois #6 and Arkansas	120 x 10^6 Btu/d MBG to electric power; 25,000-30,000 bpdoe
Louisiana					
20. Convent	Texaco; Houston Natural Gas	Feasibility study requested	Texaco with methanation	6,000 tpd	300 x 10^6 cfd HBG; 25,000 bbl/d methanol
21. West Lake	Combustion Engineering; Gulf States Utilities	Contract being negotiated	Gasification/ Electric Power	1,800 tpd high sulfur Eastern	150 MW
Texas					
22. Baytown	Exxon; Japan Coal Liquefaction Development Co.; DOE	Under construction	Exxon Donor Solvent	250 tpd	600 bbl/d Liquid fuels
23. Baytown	Exxon	Operating, commercial plans deferred	EDS	0.5 tpd	---
24. Near Baytown	Exxon; Carter Oil	Conceptual stage, operational 1987	Lurgi	45,000 tpd Texas lignite	925 x 10^6 cfd MBG
25. Near Houston	Transco	Feasibility study requested	Lurgi	Texas lignite	357 x 10^6 cfd MBG
26. Texas City	Union Carbide	18 month feasibility	---	---	357 x 10^6 cfd MBG
27. East Texas	Exxon	Feasibility study completed	Lurgi	42,000 tpd Texas Lignite	MBG
28. Bishop	Celanese Corporation	---	---	---	10,000 bpdoe methanol
29. Moore County	Mapco Inc.	Onstream 1982	---	---	1,428 bbl/d ethanol

(continued)

TABLE 6-20: (continued)

Region/State	Sponsor	Status	Process	Input	Output
REGION 6 (continued)					
New Mexico					
30. Northwest N.M.	Texas Eastern Transmission; Pacific Lighting Corporation	Feasibility study underway	Lurgi with methanation	---	250 x 10^6 cfd HBG
31. San Juan County	Texas Eastern Synfuels; Utah International	9 month feasibility study proposed; onstream 1988	Lurgi-Gas and methanol	25,000 tpd	138 x 10^6 cfd HBG; 51,500 bbl/d methanol
32. Northwest N.M.	El Paso Natural Gas Co; Pacific Gas and Electric	---	Lurgi with methanation	7,600 tpd	72 x 10^6 cfd HBG
33. Grants	Energy Transition Corporation	Price guarantee requested	---	---	1.2 x 10^6 bbl/yr methanol

cfd = cubic feet per day LBG = Low-Btu Gas MBG = Medium-Btu Gas HBG = High Btu Gas

Source: Carvitti, Szabo, and Kemner, 1981; Wett, 1981; Patel, 1981; OGJ, 1981e; Cantrell, 1981b, p. 220; Hanson, 1981.

[a] Data not available.

fuels such as methanol and gasoline (Carvitti, Szabo, and Kemner, 1981).

The nation's two largest experimental synfuels plants testing variations of an advanced coal-to-liquid process are located in the South and have completed long-term continuous runs. Outside Catlettsburg, Kentucky, Ashland Synthetic Fuels has used the H-coal process with eastern bituminous coal for more than 1,500 hours. In Baytown, Texas, the Exxon Donor Solvent plant has logged more than 3,000 hours (Wett, 1981). Among the projects aimed at making transportation fuels from coal is the W. R. Grace liquefaction plant proposed for Baskett, Kentucky. The facility would produce 50,000 bbl/d of high-octane unleaded gasoline from 29,000 tpd of high-sulfur coal and is projected to be onstream in 1986.

The Tennessee Valley Authority (TVA) has two projects which are expected to produce medium-Btu gas. The Muscle Shoals, Alabama, coal-gasification plant was retrofitted to an existing ammonia plant and began test operation in 1980. The facility consumes 200 tpd of high-sulfur, high-ash coal to produce 10 million cfd of synthesis gas; the gasifier can supply 60 percent of the daily capacity of the ammonia facility (135 tons). TVA's Murphy Hill site would convert about 20,000 tpd of eastern high-sulfur coal to medium-Btu gas that could be burned directly as an industrial fuel or used as a chemical feedstock. The gas also could be processed into pipeline quality substitute natural gas or liquid fuels. The first module, capable of processing 5,000 tpd of coal, is expected to be completed by 1985 with the entire facility completed by 1987 (Patel, 1981).

The Memphis Light, Gas, and Water Project would convert approximately 3,100 tpd of Kentucky #9 coal into 154 million cfd of medium-Btu gas (equivalent to about 10,000 bbl/d of oil). The gas could provide fuel for local industrial consumers. On the Gulf Coast, the Gulf States Utilities Company (GSU) demonstration plant is expected to produce low-Btu gas to be used for generating 150 MW of electrical power. The proposed plant would be located at GSU's West Lake, Louisiana, facility and would be capable of processing 1,800 tpd of coal. Initial work is now underway; the total program from design to operation is expected to take six years (Patel, 1981).

B. Oil Shale

Some reports have indicated that eastern oil shale could be commercially viable in today's market with special government subsidies in the form of price and purchase guarantees, tax incentives, loan guarantees, and capital grants. However, the development of new processes (such as HYTORT and Paraho) may make it economically feasible to exploit these deposits without special subsidies (Synfuels Week, 1980). By using these new processes, Devonian shales containing ten percent or more organic carbon by weight may be commercially attractive feedstocks for the production of synthetic fuels.

A geologist with the Institute for Mining and Minerals Research at the University of Kentucky has stated that commercial development of Kentucky oil shale is about five years away (Shale Country, 1981). In addition to completing resource surveys, mining plans have to be worked up and the retorting technology needs to be developed further. Even though the costs of processing and the extent of the resource are still uncertain, Phillips Petroleum and the Institute for Gas Technology (IGT) have been developing the retorting technology and have indicated that they believe an investment in the development of Devonian shale is worth the risk. The IGT has demonstrated the HYTORT process experimentally and has indicated that the process is ready for testing in a plant requiring about 2,000 to 4,000 tons of shale per day.

A number of oil shale processing facilities are being considered for the north central Kentucky area. A study conducted for the Buffalo Trace Area Development District of Maysville, Kentucky, concluded that 4.4 billion barrels of oil can be recovered from oil shale in Lewis and Fleming counties. A site specific study in Fleming County to determine the feasibility of an oil shale processing plant (Paraho process) to produce 10,000 bbl/d of oil has been completed (OGJ, 1981f) and a feasibility study is underway for a 30,000 bbl/d plant in Lewis county. In the same area, a 10,000 bbl/d plant is being considered for a Clark County, Indiana site (directly across the Ohio River from Kentucky). The first phase would be completed by 1987, with an expected total plant capacity of 50,000 bbl/d (Chemical Week, 1981).

The future development of eastern oil shale will depend, to a large degree, on the price and supply of crude oil. Estimated costs for product synthetic crude oil range from 26 to 29 dollars per barrel (first quarter 1980 dollars).

6.5.4 Environmental Issues

Some environmental problems of synfuel facilities are similar to those of any large-scale industrial activity, especially those utilizing coal, while others will be relatively unique to coal liquefaction or gasification and oil shale development. Problems will vary among areas and the types of technologies employed. Table 6-21 summarizes major environmental issues associated with producing synthetic fuels from coal and oil shale.[1] Although important differences exist among the synthetic fuel processes,

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[1] For a discussion of the impact related to coal mining see section 6.4.4.

TABLE 6-21: SELECTED ENVIRONMENTAL ISSUES FOR SYNFUELS

Production Stage	Land Use and Water Quality	Air Quality	Ecosystems	Safety and Health	Other
Conversion Processes	Potential surface and ground water pollution from holding poinds Wastewater discharges (Southeast) Disposal of large amounts of solid wastes Local land-use changes Construction on flood plains	Emissions of "criteria pollutants" (i.e., NO_x, SO_2, particulates, etc.) Fugitive emission of carcinogenic substances Possible releases of trace elements Releases during "upset" conditions Possible localized odor problems	Air pollution damage to plants Contributions to acid rain Wildlife habitat fragmentation from population increases Contributions to the "greenhouse" effect	Occupational safety and health risks from accidents and toxic chemicals Carcinogens in direct process intermediates and fuel products	Water availability issues (especially in New Mexico)
Product Transport and End-Use	Product spills from trains, pipelines, and storage	Changed automotive exhaust emissions (increase in some pollutants, decrease in others) Increased evaporative emissions from methanol fuels Toxic product vaporization	Acute and chronic damages from spills	Exposure to spills Uncertain effects of trace elements and hydrocarbons	Potential change in fuel economy Methanol corrosion and reduction of existing engine longevity

Source: Chartock et al., 1981.

there are many similarities with respect to environmental impacts. All plants transform a solid fuel, high in polluting compounds and mineral matter, into liquid or gaseous fuels containing low levels of sulfur, nitrogen, trace elements, and other pollutants. In addition to the management of waste streams (air pollutants, water effluents, or solid wastes), other environmental concerns include potential ecosystem disruptions from population increases associated with building and operating the plants, water requirements, and occupational safety and health risks.

A. Air

Large synfuel facilities generally will have lower levels of emissions of "criteria pollutants" than comparably sized coal-fired power plants. For example, a new coal-power plant meeting existing air emissions standards and capable of utilizing the same rate of coal as a 50,000 bbl/d coal liquefaction facility would produce roughly 5 to 25 times as much NO_x and SO_2, and 0.8 to 12 times as much particulates (Chartock *et al*., 1981). Air dispersion modeling for a variety of locations with meteorological conditions similar to the South have shown that coal liquefaction facilities should be able to meet standards for ambient air quality during "normal" operations (Chartock *et al*., 1981).

Another potential problem from synthetic fuel plants is odor, which can be important on a localized basis. Like petroleum refineries, H_2S is one of the major odorous emissions (MITRE, 1981) because of its relative abundance in process streams. Odor episodes outside plant boundaries are well documented for petroleum refineries (NAS, 1979). At the present time, information is not available to indicate whether odor problems from coal liquefaction facilities would be better or worse than refineries.

B. Trace Organic Compounds

Trace emissions of carcinogens formed during the conversion processes are of more concern than criteria pollutants. For example, some coal liquefaction and gasification processes produce a wide range of organic compounds including polynuclear aromatic hydrocarbons and polynuclear aromatic amines, known to be carcinogenic. Although known to be present in carbonaceous retorted shales and shale oil products, the potential hazard of such material is not accurately known (U.S., EPA, ORD, 1980). The concern is that workers and the public could be exposed through trace levels in pollution streams, accidental releases to the air and water, and direct contact with end-products. The degree of risk is uncertain due to:

- Lack of information on the precise nature of the chemical compounds produced;

- The reliability of controlling releases;
- Potential for multiple exposure paths for the populace;
- Inadequate understanding of the long term human health effects from low-level but chronic exposures; and
- Potential for detoxifying the end products.

These uncertainties exist because of the absence of commercial plant experience and the limited environmental health testing of intermediate and end products.

C. Water

Synfuel plants produce wastewater streams that contain many pollutants known to cause health and environmental problems. For example, process wastewaters will contain phenol, ammonia, polynuclear aromatic hydrocarbons, chlorides, sulfates, cyanides, and a variety of trace elements such as arsenic, cadmium, and mercury. Existing industrial wastewater treatment technologies are expected to be able to control most of these effluents in the absence of major accidents. However, it is not certain that planned wastewater treatment technologies can continuously control the trace elements and toxic organic compounds, or the potential interactions among the various pollutants associated with synfuel processes.

With respect to oil shale, construction, mining, and site use activities may result in increased sediment and dissolved solids in surface run-off and receiving streams. This source of water pollution is not unique to oil shale but can present environmental problems due to the magnitude of site activities (U.S., EPA, ORD, 1980a).

D. Solid Wastes

The disposal of solid wastes is an important environmental concern, both in terms of its long-range land-use effects and because of the possibility of toxic materials being leached from the disposal site. The magnitude of the wastes is great--over a 30 year period, a 50,000 bbl/d coal synfuels plant would produce enough ash to require one square mile of land with waste piled 50 feet high (Chartock et al., 1981). For a 50,000 bbl/d western oil shale plant (surface retorting) there will be enough spent shale generated in one month to occupy a volume of almost two million cubic feet, or about a two feet depth over a square mile (U.S., DOE, Asst. Sec. for Environment, Office of Technology Impacts, 1980). Since the yield per ton of Eastern shale is about half that of Western shale, spent shale disposal problems from Eastern development are likely to be even greater than the disposal problems associated with Western shale.

One of the major issues with the potential to impact on the future of the industry has to do with whether these wastes (or some portions thereof) should be declared "hazardous" under the 1976 Resource Conservation and Recovery Act (see Chapter 15) and, thus, be subject to very stringent disposal requirements. If this were to occur, it could have serious economic consequences for the synfuels industry.

E. Other Impacts

Other environmental issues in addition to those related directly to gaseous, liquid, and solid wastes include the following:

- The extremely large plant size--requiring approximately 2,000 to 3,000 acres for a 50,000 bbl/d facility--creates aesthetic and land-use impacts;
- Large shipments of coal to plants located away from mines create noise, dust, and disruptions to local road traffic; and
- The consumption of water for plant operations--anywhere from 3,400 to 5,900 AFY for a 50,000 bbl/d coal liquefaction facility--raises concerns over the appropriate use of an increasingly scarce resource, especially in areas like West Texas and New Mexico.

6.6 NUCLEAR ENERGY RESOURCES

6.6.1 Introduction

In the early 1970's it was generally thought that nuclear power would be the largest supplier of electric energy by the end of this century. However, it is now apparent that the role of nuclear power as a source of energy in the U.S. will not be as great as once projected. Recent estimates (U.S., DOE, Asst. Sec. for Policy and Eval., 1980; OGJ, 1981g) indicate that nuclear power could provide almost one-quarter (24 percent) of the nation's power needs for electricity by the end of the decade, and that percentage is expected to remain relatively constant through the year 2000 (25 percent). This reduced role of nuclear power is even more dramatic when one considers that these recent projections are based on energy consumption expectations that are greatly reduced compared to the projections made in the early 1970's.

Within the Sunbelt, nuclear power will be an important source of energy in Region 4, particularly the area supplied by the Tennessee Valley Authority and the Carolinas, for the next 20 to 30 years. Although the states in Region 6 are expected to rely very little on nuclear power as a source of energy, this area is a source of uranium and a potential repository for spent fuel. Thus, the South is involved in all stages of the nuclear power cycle.

This section describes the distribution of uranium resources in the South, discusses the current and future status of nuclear power generation, and summarizes the environmental issues associated with the nuclear power cycle.

6.6.2 Resource Distribution and Production[1]

The western part of Region 6 is an important source of uranium for the nuclear power industry. The DOE (Off. of Uranium Resources and Enrichment, 1980) provides separate estimates of the quantities of uranium in cost categories of 30, 50, and 100 dollars per pound of yellowcake (U_3O_8). The reserves in these cost categories represent the amount of U_3O_8 in ore that is estimated to be recoverable at those costs or less in the mining process.

As of January 1, 1980, 30-, 50-, and 100-dollar reserves were estimated to be 645,000, 936,000, and 1,122,000 tons respectively. Over 50 percent of the total U.S. reserves in each cost category are located in Region 6, particularly New Mexico, and to a much lesser extent, Texas (Table 6-22). Together, these states account for 59 percent of the total 30-dollar reserves, 54 percent of the 50-dollar reserves, and 51 percent of the 100-dollar reserves.

Historically, New Mexico has been the leader in uranium production; in 1979, 40 percent (8,200 tons) of the total U.S. U_3O_8 came from New Mexico. Recently Texas has begun to make more of a contribution to U.S. uranium supplies. The cumulative production of U_3O_8 from Texas has been about 15,000 tons. Current production of uranium in Texas is about 2,700 tons annually and Texas accounted for 13 percent of the total U.S. production in 1979. Fisher (1980) estimates that the Texas resource base could support production levels up to about twice the current levels.

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[1] Uranium reserves are the estimated quantities of uranium which occur in known deposits of such grade, quantity, configuration, and depth that they can be recovered at, or at less than, a specified cost with current mining and processing technologies. The discussion of resource distribution and production is based primarily on U.S., DOE, Off. of Uranium Resources and Enrichment, 1980.

TABLE 6-22: DISTRIBUTION OF URANIUM RESERVES

	$30 Reserves		$50 Reserves		$100 Reserves	
	tons U_3O_8	% total tons	tons U_3O_8	% total tons	tons U_3O_8	% total tons
New Mexico	338,550	52	448,700	48	512,300	46
Texas	43,300	7	55,800	6	61,000	5

Source: U.S., DOE, Off. of Uranium Resources and Enrichment, 1980.

Almost sixty percent of the U.S. uranium mill production capacity is located in the South, primarily in New Mexico and Texas (Figure 6-5). As of January 1, 1980, the conventional mills in these two states accounted for approximately 55 percent (11,000 tons U_3O_8/year) of the total U.S. production capacity. In addition, Texas has the capacity to produce 1,200 to 1,400 tons of uranium from solution mining, while Florida and Louisiana can produce between 500 and 700 tons of uranium per year from phosphoric acid byproducts.

Table 6-23 indicates the acreage of mining claims and state, federal, Indian, and fee lands in the South held for uranium exploration. These data also include lands held for production and auxiliary purposes as well as leases and claims held by individuals and/or companies in anticipation of exploration interest. While the South's share of the total U.S. land held for uranium exploration and mining has decreased since 1976, the absolute acreage devoted to this use has increased in New Mexico and Texas. Texas continues to lag far behind New Mexico in terms of acreage set aside for uranium exploration and mining, but between 1976 and 1980 Texas uranium acreage increased substantially--147 percent or 917 acres.

Not only is more Texas land being set aside as a possible source of uranium, but drilling activity for exploration and development is increasing. Nationally, the total drilling footage reported in 1979 was 13 percent lower than reported in 1978. Texas was one of the few states that reported an increase in drilling activity, accounting for 20 percent of U.S. total footage

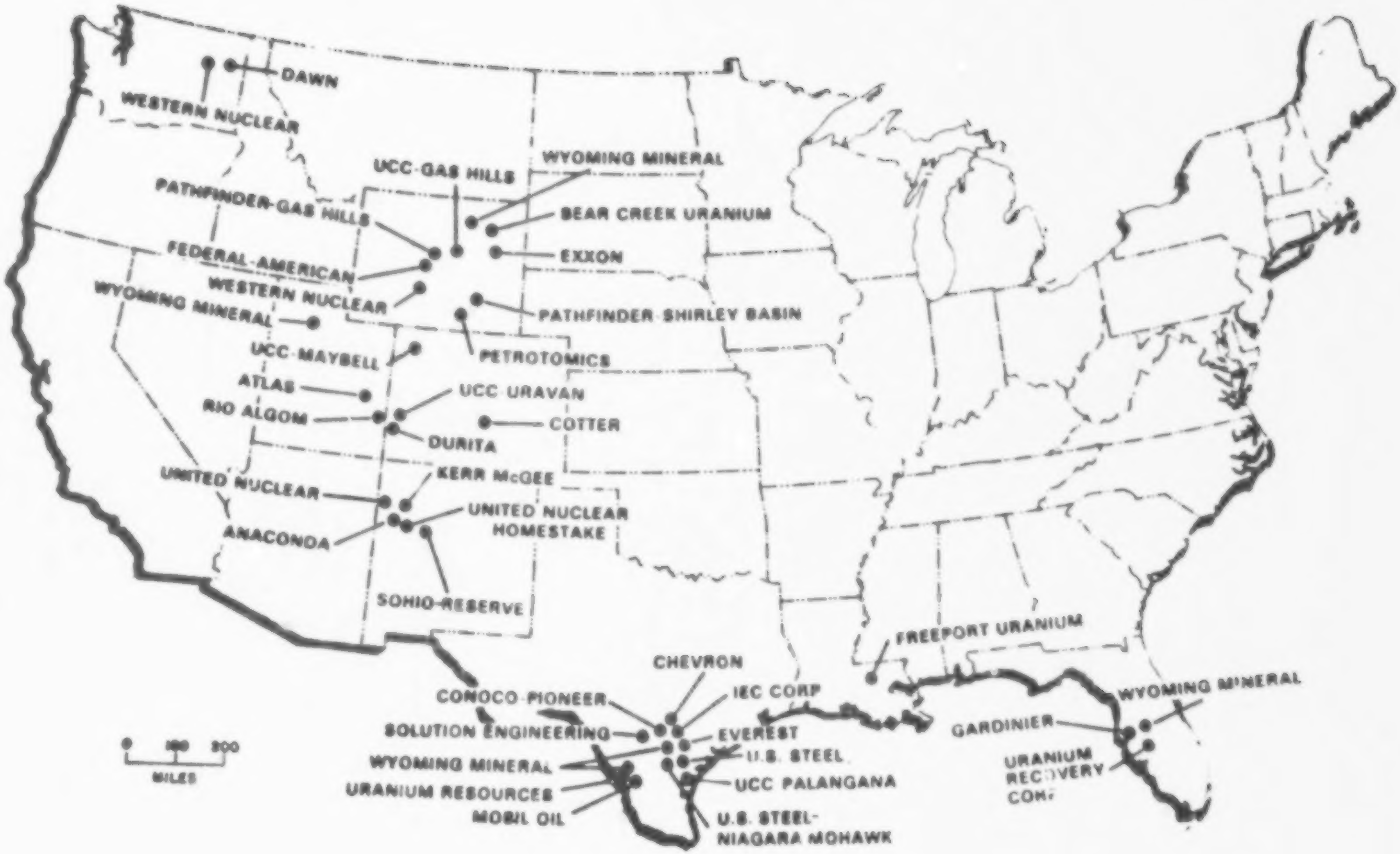

Figure 6-5: Operating Uranium Mills in the U.S., January 1, 1980

Source: U.S., DOE, Off. of Uranium Resources and Enrichment, 1980.

TABLE 6-23: LAND HELD FOR URANIUM EXPLORATION AND MINING (thousands of acres)

	1-1-1976	% of U.S. Land Held	1-1-1980	% of U.S. Land Held
New Mexico	3,663	16	4,652	13
Texas	622	3	1,539	4

Source: U.S., DOE, Off. of Uranium Resources and Enrichment, 1980.

(Table 6-24). About 93 percent of the drilling in Texas was devoted to exploration activities in search of new ore deposits or extensions of known deposits. In New Mexico, drilling was almost evenly divided between exploration and development drilling.

6.6.3 Current and Future Status

A. Nuclear Power Generation

As of January 1, 1981, the United States had 75 licensed nuclear reactors with a generating capacity of slightly over 56,000 MW. Even though 101 units are under construction or planned, the current projection of 176 nuclear reactors is substantially less than the 236 units operating or planned in 1975 (U.S., Pres. Comm., 1980). Uncertainty about future energy demands, substantial public opposition, rising construction costs, and new regulatory requirements imposed after the accident at the Three Mile Island power plant have led to a cautious wait-and-see attitude for many utility planners.

As indicated by the data in Table 6-25 orders for new nuclear installations virtually have stopped. From 1972 through 1974, 100 new nuclear plants (one to four units each) were ordered. The number of orders then dropped off drastically; only 2 plants were ordered in 1978 and none were ordered in 1979 or 1980. At the same time, the number of units cancelled increased substantially. Between 1978 and 1980, orders for 35 units were cancelled, as compared to 14 cancellations between 1972 and 1974.

TABLE 6-24: 1979 URANIUM DRILLING (millions of feet)

	Exploration	% of U.S. Total	Development	% of U.S. Fotal	% of All Drilling
New Mexico	3.0	11	3.3	24	15
Texas	7.6	28	.6	4	20

Source: U.S., DOE, Off. of Uranium Resources and Enrichment, 1980.

TABLE 6-25: THE MARKET FOR NUCLEAR POWER

	1972-1974	1975-1977	1978-1980	% change 1974-1980
Operating units at the end of the period	53	67	75	+42
New plant orders[a]	100	11	2	-98
Unit orders cancelled	14	22	35	+40

Source: Atomic Industrial Forum, 1981.

[a] A plant consists of one to four units or reactors.

The slowdown in construction of nuclear power plants in the Sunbelt has not taken place to the same degree as in other regions of the country. As of January 1, 1981, seven of the Sunbelt states accounted for 27 percent of the operating units in the U.S and 31 percent (17,331 MW) of the generating capacity. Alabama has five licensed units, Florida and South Carolina have four, Arkansas, Georgia, and North Carolina each have two operating units, and Tennessee has one (Figure 6-6). In addition, almost half (46 percent) of the units with construction permits are located in the South, as are a third of the units that have been sited but are still in the planning stage. If all of the units with construction permits or that are planned are completed, the South will have a generating capacity of 67,082 MW, 40 percent of the total U.S. capacity from nuclear power (Table 6-26).

In an attempt to promote the commercial use of nuclear power, nuclear licensing reform efforts are underway (BNA, 1981d; BNA, 1981e). Currently, it takes 10 to 14 years to complete the licensing process; alternatives are being considered that would reduce the lag to six to eight years. Site-banking also is being considered. Under this plan, the Nuclear Regulatory Commission (NRC) would approve a preliminary bank of acceptable sites for construction of nuclear plants and the utilities would choose from among these sites.

Within the Sunbelt, some states in Region 4 in particular appear to be committed to increasing substantially the use of nuclear power as a source of electricity generation. Currently, 90 percent of the nuclear generating capacity in the Sunbelt is located in Region 4; in Region 6, only Arkansas has operating nuclear units. If all of the proposed units in the Sunbelt are completed, Region 4's share of the South's generating capacity would decrease to 81 percent; however, the absolute capacity would increase significantly from 15,569 MW to 54,167 MW (Table 6-26). This is in large part due to the aggressive stance taken by the Tennessee Valley Authority (TVA) and the Carolinas. All new power generating capacity coming on line for the TVA region (Tennessee, parts of Alabama and Mississippi) over the next ten years will come from nuclear units.

The TVA has nine units under construction in six plants, and construction of three units has been deferred until the mid-1990's. According to a forecast made by TVA, if the two units at the Phipps Bend plant and two units at Hartsville were cancelled, and the two units at Yellow Creek were delayed, TVA would still have a reserve capacity of about 20 percent by the year 2000. Rather than cancel or delay construction of any further units, TVA officials say they hope to complete construction and then transmit the electricity to parts of Arkansas, Louisiana, and Mississippi that are heavily dependent on oil and natural gas (*Commercial Appeal*, 1980a).

NUCLEAR POWER REACTORS IN THE UNITED STATES

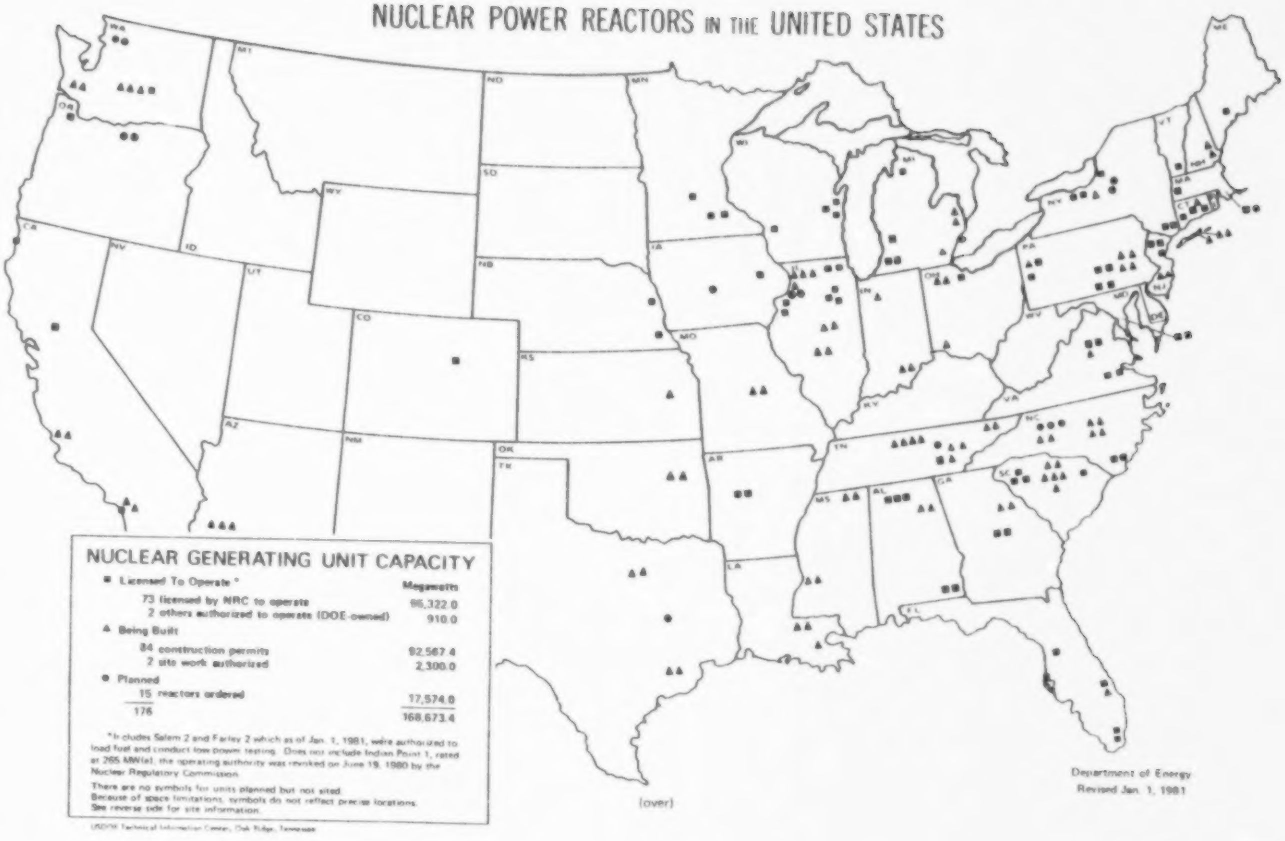
NUCLEAR GENERATING UNIT CAPACITY
■ Licensed To Operate*
Megawatts
73 licensed by NRC to operate 96,322.0
2 others authorized to operate (DOE-owned) 910.0
▲ Being Built
84 construction permits 92,567.4
2 site work authorized 2,300.0
● Planned
15 reactors ordered 17,574.0
176 168,673.4
*Includes Salem 2 and Farley 2 which as of Jan. 1, 1981, were authorized to load fuel and conduct low power testing. Does not include Indian Point 1, rated at 265 MW(e), the operating authority was revoked on June 19, 1980 by the Nuclear Regulatory Commission.
There are no symbols for units planned but not sited.
Because of space limitations, symbols do not reflect precise locations.
See reverse side for site information.
USDOE Technical Information Center, Oak Ridge, Tennessee
(over)
Department of Energy
Revised Jan. 1, 1981

Figure 6-6: Nuclear Power Reactors in the U.S.

Source: U.S., NRC, 1981.

TABLE 6-26: NUCLEAR GENERATING CAPACITY IN THE SUNBELT (MW)

	As of 1-1-81	Total Potential Capacity
Region 4		
Kentucky	4,844	7,270
Florida	3,013	3,823
Georgia	1,561	3,781
Mississippi	---	5,070
North Carolina	1,642	11,442
South Carolina	3,361	10,391
Tennessee	1,148	12,390
Total	15,569	54,167
Region 6		
Arkansas	1,762	1,762
Louisiana	---	2,981
Oklahoma	---	2,300
Texas	---	5,872
Total	1,762	12,915
Sunbelt Total	17,331	67,082

Source: U.S., NRC, 1981.

Other utilities also are moving ahead despite construction lags and rapidly escalating construction costs. Georgia Power Company was near bankruptcy in the mid-1970's causing a two-year delay in completing two 1,100 MW nuclear units now scheduled to be on line in 1985 and 1987. In order to meet some of the increased costs for the construction of St. Lucie 2, Florida Power and Light is looking to other state utilities for assistance. By the time the unit is on line they expect to have sold up to 22 percent of its generation capacity. Construction delays and financial constraints also have delayed four North Carolina units under construction by Carolina Power and Light Company. Originally scheduled for 1977, 1978, 1979, and 1989, the timetable has slipped to 1985, 1988, 1990, and 1994.

Some utilities previously committed to unclear power may be reexamining their position. For example, Duke Power Company has eight units on order or with construction permits in North Carolina and South Carolina, but other energy alternatives are being considered (BNA, 1980a). In northeastern Oklahoma, the Black Fox nuclear power plant project is not likely to be completed because the Public Service Company has not been able to secure a rate increase sufficient to pay for the plant's revised price tag of 9 billion dollars. Currently, the plant is about 2 percent complete after an investment of 300 million dollars. Construction has gone as far as it can without a full NRC permit and the project is costing about 2 million dollars per month while the plant site stands idle. Before granting a full construction permit, the NRC would take into account the Public Service Company of Oklahoma's ability to finance the project (Malone, 1981; Vandewater, 1981).

B. Hazardous Waste Disposal

The disposal of radioactive wastes is one of the most intensely debated issues related to nuclear power. High-level and low-level waste are precisely defined categories of radioactive waste requiring different procedures for proper handling and disposal. High-level waste includes spent nuclear reactor fuel, wastes produced from spent fuel reprocessing, and certain wastes associated with the production of nuclear weapons. All other waste is classified as low-level wastes and includes anything (e.g., clothes, and tools) contaminated by activities using radioactive materials.

For a commercial nuclear reactor, the most serious high-level waste disposal problem has to do with spent fuel. A typical nuclear plant (1,000 MW) produces about 30 tons of spent fuel a year (Kuziak and Havemann, 1980). Most nuclear plants have made provision for on-site storage of spent fuel, but this method of disposal cannot go on indefinitely. Even with the recent Reagan administration decision to reverse the ban on private reprocessing of used reactor fuel, maintaining adequate disposal space at the unit sites will become increasingly difficult (Marshall, 1981).

About 6,000 metric tons of spent fuel currently are stored at reactor sites around the United States. By 2000, this figure is projected to increase tenfold, creating a demand for away-from-reactor storage capacity of over 16,000 metric tons (BNA, 1981f). In spite of plans by some utilities for increasing the capacity for on-site storage, some reactors may have to shut down in the next few years (NAS 1979b). Between 1985 and 1990, the demand for away-from-reactor storage will probably be about 1,800 metric tons; demand will increase rapidly to about 16,000 metric tons during the decade of the 1990's.

The current administration's policy is that away-from-reactor storage will not be a federal undertaking. Rather, it is expected that private industry will take responsibility for the processing of nuclear waste (BNA, 1981d). However, the government does accept full responsibility for permanent isolation of high-level radioactive wastes. Three permanent disposal sites are to be chosen and exploratory shafts constructed by 1985. The first federal disposal site is expected to be ready for licensing by 1988 (Marshall, 1981).

There are those who argue that the technology for the safe disposal of radioactive wastes, particularly high-level wastes, is available and that burial or geological isolation is a workable solution (NRC, CONAES, 1980). Others believe that wastes should be stored in ground level vaults. Salt domes are among the geological formations being considered as potential deposition sites. If isolation in salt domes is determined to be a workable solution, the Gulf Coast area could be tapped as a major repository for radioactive wastes. Sites in Texas, Louisiana, and Mississippi are being considered as repositories for high-level wastes (Figure 6-7).

Low-level wastes are somewhat less controversial but can be highly dangerous. Typically, these wastes are stored in 55-gallon drums and buried in trenches about 30 feet deep. Currently, three licensed facilities are available for the disposal of the 3.5 million cubic feet of low-level wastes generated each year (43 percent comes from nuclear power plants). In addition to Barnwell,

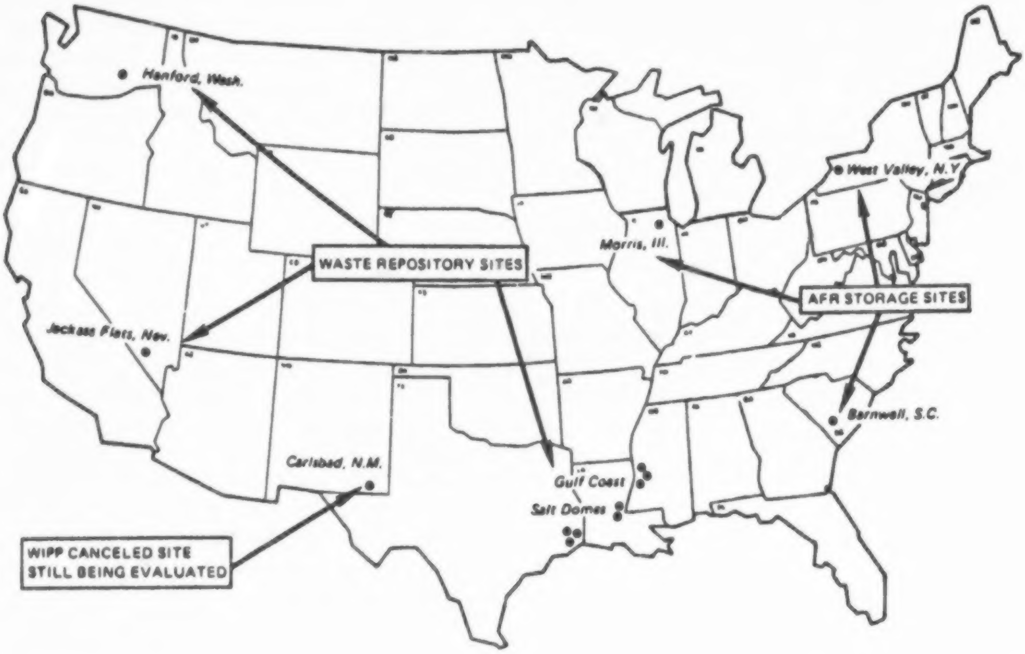

Figure 6-7: Proposed Sites for a Permanent High Level Radioactive Waste Repository

Source: Nuclear Industry, March 1980, p. 3.

South Carolina, facilities are located in Nevada and Washington. Because of the closing of sites in New York and Kentucky due to waste leakage, Barnwell is now accepting all of the low-level waste produced in the East. Since this section of the country has a large number of nuclear power plants and other radioactive waste-producing sources, Barnwell receives approximately 80 percent of the total volume of low-level waste shipped in the U.S. (SSEB, 1981).

The volume of waste accepted at the Barnwell facility has increased from 49,583 cubic feet in 1971 to 2,254,972 cubic feet in 1979. The original operating license restricted the facility to not more than 200,000 cubic feet per month. By the last quarter of 1981, the allowable volume per month had been reduced to 100,000 cubic feet.

The transportation of radioactive wastes to interim or permanent disposal sites presents major environmental issues. At present, all shipments of spent fuel are going to interim storage facilities until the government picks a permanent disposal site. Between July 1979, and September 1980, 108 shipments (51 tons) of spent fuel passed through 33 states, mostly on interstate highways (Commercial Appeal, 1980b). Seven of these states are in the Sunbelt--Kentucky, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas. Apprehension over the risks involved has led almost 100 communities and one state (Louisiana) to pass ordinances prohibiting shipments of spent fuel through their areas. A study conducted for the NRC estimated that a serious radiation release in a large metropolitan area could result in up to two billion dollars in economic losses and several hundred additional cancer cases.

As of October 1980, only 17 nuclear plants have approved shipping routes for spent fuel; the remainder have on-site storage capacity remaining (Commercial Appeal, 1980b). In addition to the transportation of high-level wastes, low-level wastes are transported frequently and in large volumes. For example, hundreds of thousands of barrels of low-level radioactive waste are trucked to Barnwell, South Carolina, each year from nuclear power plants, factories, and medical centers around the country. In 1980, 71,827 cubic feet of waste was shipped from Florida alone--just under half of that from Florida Power Corporation's Crystal River nuclear plant. Given the rate of current and planned construction of nuclear facilities in the South, the issue of nuclear waste disposal is likely to remain a major concern.

6.6.4 Environmental and Health Impacts

Table 6-27 presents environmental issues associated with the nuclear fuel cycle. Many of the environmental issues result from the mining and milling of the uranium ore. Danger from exposure

TABLE 6-27: SELECTED ENVIRONMENTAL ISSUES FOR NUCLEAR ENERGY

Production Stage	Water Quality	Air Quality	Land Use and Solid Waste	Health, Safety, and Radiation	Other
Mining and milling (New Mexico and Texas)	Aquifer disturbance; runoff control; surface water contamination	Dust and radon emissions	Subsidence; tailings disposal Habitat disturbance	Exposure of miners to radioactivity Mine accidents	
Conversion, enrichment, fabrication, and reprocessing (Oklahoma, Kentucky, and Tennessee)	Thermal pollution	Potential radioactive emissions	Sludge disposal Low and high level radioactive waste disposal	Exposure of operators Accidents	Transportation accident risks
Power reactors (regionwide)	Thermal pollution Low level radiation	Potential radioactive emissions	Habitat fragmentation	Exposure of operators Accidents	Plant siting; accident risks
Radioactive waste disposal (South Carolina and possibly Gulf Coast	Aquifer contamination		Permanent commitment of land	Exposure of operators	Siting; long term monitoring and protection

during these processes is high and the effects are long-term and may not become evident (e.g., in the form of cancer) for 10 to 20 years. In Region 6, primarily Texas and New Mexico, nuclear industry surveys indicate that mining and milling are expected to increase about 400 percent between 1975 and 2000 (U.S., EPA, ORD, 1980b). Environmental problems could result from this increased level of activity. Water pumped from the mines contains dissolved and suspended solids and could affect local water quality. The residue of the milling process includes radioactive solid and liquid tailings that retain about 85 percent of the total radioactivity of the ore from which they were produced (U.S., DOE, Off. of Environmental Assessments, 1981). The radioactive material in abandoned tailing piles may be dispersed in the air by wind and contaminate ground water through leaching by rain. Radiation exposure also is possible by inhalation of emissions of radon-222 gas.

In addition to issues related to the disposal of radioactive wastes, public concern about the use of nuclear power has focused on: (1) the safety of the routine operation of the nuclear fuel cycle and of reactors; and (2) the possibility of major nuclear accidents. The radiation to which the public is exposed during the normal operation of a nuclear power plant is lower than that emitted during an X-ray or from naturally occurring radioactivity. Small quantities of short-lived radioactive gases and airborne particles are released during the normal operation of light-water reactors, but the exposure levels of individuals are small when these gases and particulates are dispersed in the environment. However, the health risks of long-term exposure to low-level radiation are a continuing concern and some studies have suggested that even low levels of radiation can be carcinogenic or mutagenic (Schurr et al., 1979). The liquid effluents released by nuclear power plants contain little radioactivity; the water is treated by processing facilities and most of it is recycled as makeup water. The low-level radioactive waste products removed during processing are solidified, drummed and buried. The primary concern is the possibility that the radioactive material will leach into the ground water system.

A great deal of uncertainty surrounds the estimates of risk attached to the possibility of reactor accidents. The Rasmussen Report (U.S., NRC, 1975) on reactor safety (also known as WASH-1400) attempted to estimate the probability that nuclear accidents of varying severity would occur and that a significant release of radioactivity would be carried to a location where it could expose a population to possible health risks. The report concluded that the chance of a severe accident occurring is extremely small. However, the report was severely criticized for some of the methodology and analytical techniques used and the NRC withdrew its endorsement of the executive summary of the report. The Risk and Impact Panel that participated in the National Academy of Sciences (NRC, CONAES, 1980) assessment of alternative energy systems concluded that, even with the upward correction of the WASH-1400 estimates, nuclear power is acceptable provided the rate of expansion is consistent with the rate of improvement of knowledge about accident risks. However, the serious accident at Three Mile Island raises serious questions as to the reliability of these previous accident risk estimates--and their economic consequences for the affected utility. And, even if the estimated risks associated with normal operation or major accidents are small, the risks are increased substantially in the Southeast as nuclear power plant construction continues.

Nuclear power is the most controversial source of energy among the current alternatives. In recent years, intense debate has taken place over issues of nuclear power plant safety, hazards involved in nuclear waste disposal, and other questions about the economics of nuclear power. Although some areas of Region 4 are moving ahead with the construction of nuclear plants, the degree to which nuclear power will contribute to the energy future of the South will depend on the successful resolution of these many issues.

6.7 RENEWABLE BIOMASS ENERGY

6.7.1 Introduction

The renewable nature of biomass and the abundance of biomass resources make it a potentially attractive source of energy. Frequently, biomass is characterized as a resource capable of providing nonpolluting, safe fuels and "bioenergy" is considered to be relatively benign. Besides being renewable, biomass contains virtually no sulfur or radioactivity. On the other hand, biomass generally has high ash content and low energy density. A large-scale development of biomass resources could lead to environmental problems related to combustion emissions and residues as well as serious land use issues (Budiansky, 1980).

Although biomass resources are not expected to make significant contributions to national energy supplies in the next 20 years, localized development is already taking place. The Sunbelt, particularly the Southeast, with its forests, prime cropland, and long growing season is an attractive location for the development of biomass resources for energy. This section discusses some of the uncertainties related to the future of biomass energy, the current and future status of various biomass resources, and identifies some of the environmental issues associated with biomass energy.[1]

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[1] The information presented in this section is based on, to a large degree, U.S., Congress, OTA, 1980.

6.7.2 Factors Affecting Biomass Energy Development

Many economic, technological, and political factors affect the future of energy production from biomass. These include:

- Price of competing fuels (oil, gas, and coal);
- The availability of government subsidies;
- Competition for wood and grain for energy and non-energy uses;
- Competition for land; and
- The efficiency of biomass conversion technologies.

Table 6-28 presents estimated production costs for various types of biomass energy products and feedstocks. In some cases, biomass could be competitive with fossil fuel. For example, wood gasification in an industrial facility could be competitive with #6 residual oil (a nearly perfect substitute) when air-blown wood gasifiers are available through mass production (Table 6-29). Similarly, gas from wood in a commercial facility could be competitive with #2 fuel oil.

As stand-alone fuels, ethanol and methanol are not directly competitive with gasoline. When added to gasoline, however, alcohol raises the octane content and improves engine efficiency. Thus, the Office of Technology Assessment (OTA) estimates that, used as an additive, ethanol could be competitive without subsidies if its cost is no more than 1.7 to 2.5 that of crude oil.

Although prices currently are not competitive with gasoline, federal and state subsidies create economic incentives for alcohol fuels production. In the Sunbelt, the combination of state and federal subsidies in the form of exemptions from excise taxes ranges from $33.60 per barrel of ethanol in South Carolina to $56.70 per barrel in Arkansas.

However, federal loan guarantees and grants have been cut by the Reagan administration. At a Washington conference on alcohol fuels held in late October 1981, potential producers and buyers were told to expect less government involvement and to "use creativity" in establishing a market. The DOE recently has indicated that further solicitations for loan guarantees are not likely. Bankers attending the conference stated that without federal loan guarantees alcohol fuel producers, particularly small companies with a small range of products, will have difficulty convincing banks to lend them money; thus, development would likely be curtailed (BNA, 1981g).

TABLE 6-28: BIOMASS ENERGY PRODUCTS, FEEDSTOCKS, AND COSTS

Product	Feedstock	Facility Size	Production Costs $/million Btu
Solid fuel	Wood[a]	Industrial[b]	1.88
	Herbage[a] and Crop residues[a]	Industrial	2.30 - 3.10
Gas[c]	Wood[a]	Industrial	3.60
		Commercial[d]	5.50
	Crop residues	On-farm	4.60[e]
Methanol	Wood[a]		11.80 - 17.30
Ethanol[f]	Corn	Commercial	11.26 - 14.00
	Grain sorghum	Commercial	10.32 - 13.04
	Sweet sorghum	Commercial	14.82 - 19.33

Source: Compiled from U.S., Congress, OTA, 1980.

[a] Wood, herbage, and crop residues are assumed to cost $30 dry ton.

[b] Feedstock capacity of 250 dry ton/day at a 90 percent load factor.

[c] Assumes availability of mass produced, air blown gasifiers.

[d] Feedstock capacity of 30 dry ton/day at a 25 percent load factor.

[e] Includes feedstock costs only.

[f] Assumes the following feedstock prices: corn $2.44/bu, grain sorghum $2.23/bu, sweet sorghum $15.00/ton.

TABLE 6-29: FOSSIL FUEL COSTS, MID-1980

	Cost ($/million Btu)
Crude oil ($30 bbl)	5.17
#2 fuel oil ($0.80 gal)	5.80
#6 residual oil ($0.60 gal)	4.80
Gasoline ($1.10 gal)	8.71

Source: Compiled form U.S., Congress, OTA, 1980.

Even some larger companies have felt the impact of the federal government's stance on the development of alcohol fuels. Officials of the Great Western Sugar Company blamed escalating construction costs and the administration's "uncertain attitude" about loan guarantees for manufacturing synthetic fuels when they announced cancellation of a 350 million dollar gasohol plant addition to their sugar refinery in Reserve, Louisiana. The plant was scheduled to begin processing 83,000 bushels of corn per day into alcohol, high fructose corn syrup, and animal feed by-products by March, 1983 (Heffron, 1981).

Conflicts over the use of grains for energy production rather than for food, feed, and export will not arise in the near term because alcohol production will be limited by slow development and plant capacities, rather than by the availability of grain feedstocks. Analyses indicate that alcohol production will not begin to affect corn availability, for example until ethanol production exceeds one billion gallon per year, which requires 400 million bushels of corn (Collins et al., 1981). Current projections estimate that up to three or four billion gallons of ethanol could be produced annually before resulting in significant effects on the availability of corn (SERI, 1980; Schnittker, 1980).

The quantity of land available for energy related biomass crop production largely will depend on the expected demand for grains for food. These estimates are subject to a high degree of uncertainty and OTA estimates that the amount of land available for biomass could range from zero to 65 million acres in 2000, depending on the demand for grains. These and other uncertainties make projections about the future of biomass energy tenuous at best.

6.7.3 Current and Future Status

Biomass fuels accounted for about 2 percent (1.5 Q's) of U.S. energy consumption in 1979. Most of this fuel, about 87 percent, is used for process energy in the forest products industry; the remainder is consumed as firewood and charcoal for home heating. Depending on the availability of cropland, improved crop yields, development of efficient conversion processes, proper resource management, and the level of government support, the OTA (1980) estimates that biomass energy sources could produce as few as 4 to 6 Q's/year, or as much as 12 to 17 Q's/year by 2000.

The OTA estimate is consistent with other estimates from studies by the Harvard Business School (Stobaugh and Yergin, 1979), University of Oklahoma (Radovich, 1979), and U.S. DOE (Asst. Sec. for Environment, Off. of Technology Impacts, 1980). While the mix of sources is somewhat different, the total maximum amount of energy available seems to be consistent at about 16 Q's (Table 6-30). Given the potential constraints discussed previously, the lower production estimates probably are more likely.

TABLE 6-30: ESTIMATES OF BIOMASS ENERGY POTENTIAL BY 2000 (in Q's)

Energy Source	Office of Technology Assessment[a]	Alternative Estimates
Wood	5.0 - 10	6[b]
Grasses	1.3 - 5	
Crop residues	0.7 - 1	6[c]
Agricultural wastes and manure	0.2 - 0.5	3[b]
Ethanol grains and sugar crops	0 - 0.3	0.9[d]
Total	7.2 - 16.8	15.9

Sources: [a]U.S., Congress, OTA, 1980; [b]Maidique, 1979; [c]Radovich et al., 1979; [d]U.S., DOE, Asst. Sec. for Environment, Off. of Technology Impacts, 1980.

A. Wood

Wood is the largest potential source of biomass energy and the large stand of commercial timber in the Sunbelt makes the area a potentially major user of wood as a source of energy (see Ch. 9 for further description of wood resources in the Sunbelt). One study indicates that the South is projected to produce between 2 Q's and 4 Q's of wood energy by 2000--about 40 percent of the nation's total wood energy (compiled from U.S., Congress, OTA, 1980). Most of the wood fuel would be drawn from by-products of wood processing (sawdust and paper-pulping liquor) and from forest management techniques to increase yields (thinning, clear-cutting and replanting, and collecting of logging residues). The demand for mill residues, however, is already high. In 1970 only 28 percent of all mill residues were left unused and by 1995, it is anticipated that virtually all of the mill residues will be used by the forest products industry for either energy (nonalcohol) or production of end products (Collins *et al*., 1980). Logging residues are in less demand than mill residues but high collection costs and lack of collection machinery could limit their accessibility and desirability as a feedstock.

Direct burning currently is the most common form of generating energy from wood and is used as a source of heat for industrial boilers and space heating. With improvements in gasification technology, and the use of automatic air-blown gasifiers attached to boilers, wood could become a much more attractive fuel compared with oil, gas, and coal (U.S., Congress, OTA, 1980). Wood liquefaction to methanol and ethanol technically is feasible and wood methanol can be produced at a cost comparable with methanol from grain and sugar. In 1990, wood could be used to produce about 6.2 billion gallons of methanol with approximately 4.5 billion gallons coming from the South, particularly Region 4, (MITRE, 1979). This does not include production from silviculture energy farms.

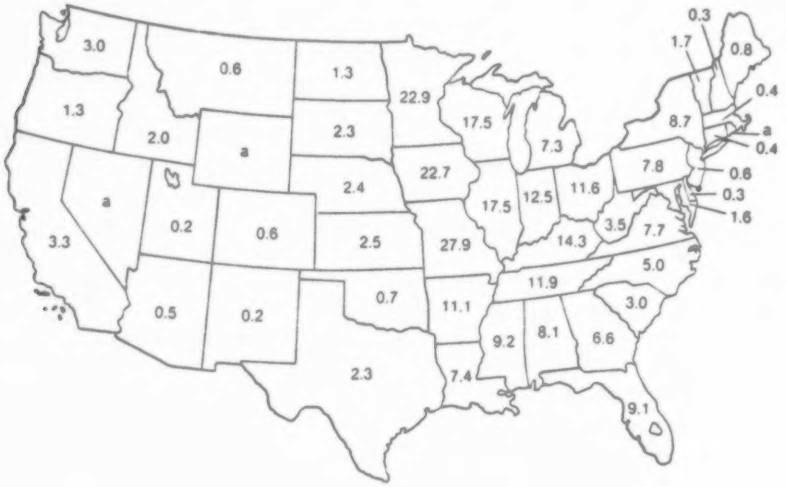
B. Grasses and Crop Residues

A substantial quantity of energy potentially is available from grasses and legumes. By more intensive cultivation of existing hayland and pasture, grasses could supply from 1.3 Q's to 2.7 Q's per year in the short-term. Use of marginal cropland for grass cultivation could boost energy production to 5 Q's per year by 2000 (U.S., Congress, OTA, 1980).

About 20 percent of residues left behind after crop harvesting could be used for energy producton. Residues currently could supply from 0.7 Q's to 1.0 Q's per year, depending on crop yields. If food production increases by 20 percent in 2000, crop residues could provide 0.8 Q's to 1.2 Q's per year (U.S., Congress, OTA, 1980).

As shown in Figure 6-8, the Sunbelt accounts for 31 percent of usable grasses and crop residues nationwide. Kentucky, Tennessee, Florida, Mississippi, and Alabama in Region 4 and Arkansas and Louisiana in Region 6 have the greatest amount of potential feedstock. The potential for obtaining additional cropland for grass production, however, depends on competition for additional land from crops such as wheat and corn.

Like wood, grasses and residues can be burned directly, liquefied, or gasified. Since the feedstocks are quite bulky, they would likely be used at the site of production (on the farm) for crop drying, fuel for irrigation pumps, and space heating. The use of these feedstocks for commercial alcohol production could be constrained by a number of factors, including: increased demand for fertilizer, year-to-year fluctuation in residue availability, and difficulties associated with collecting, storing, and processing the feedstocks due to their low density. For example, a 20 million gallon per year (MMgpy) ethanol plant would require 55 acres of stalks piled 30 feet deep to keep it running (Peart, 1979).



[a]Less than 0.1.

Figure 6-8: Usable Crop Residues and Potential Near-Term Herbage Production (million dry ton/year)

Source: U.S., Congress, OTA, 1980.

C. Grain and Sugar Crops

The potential for alcohol fuels from biomass is highly dependent on the feedstock used to produce the fuel. Grains and sugar crops are among the most frequently considered feedstocks for alcohol (ethanol) production. According to estimates made by the DOE the United States consumed approximately 900 million gallons of gasohol in 1980, requiring 90 million gallons of ethanol. With total U.S. gasoline consumption at 110 billion gallons per year (bgpy), gasohol represents a small fraction (less than 0.1 percent) of the current fuel supply. The output of ethanol plants in the U.S. is expected to reach 500 to 750 MMgpy by 1985, about one bgpy by 1990 and approximately two bgpy by 1995 (Stokes and Waterland, 1981). Even with this substantial growth rate and gasoline consumption optimistically estimated to be as low as six MMbbl/d, ethanol production in 1990 will meet but a small portion (about 0.7 percent) of our gasoline demand.

While the greatest potential for alcohol fuels comes from wood, grass and legume herbage, and crop residues, commercial processes do not yet exist and grains and sugar crops will be the major feedstock for the next ten years. Grains are less expensive to store and process but sugar crops produce more ethanol per unit of input (Plotkin and Bull, 1981). Currently, corn is the only crop grown in the U.S. on a large enough scale to significantly impact biomass alcohol production. However, extremely large amounts of land would be required to produce a meaningful supply of ethanol. For example, in 1976 Florida farmers planted 480,000 acres in corn with a yield of 60 bushels per acre. If 500,000 acres were allocated to corn, yields were high (60 bushels per acre), and the entire crop was used for ethanol production, Florida would produce 7.9 million gallons of ethanol--displacing only 1.6 percent of its 1977 gasoline consumption (La Hart, 1981).

Nevertheless, nearly all of the proposed ethanol plants in the Sunbelt will use grain, principally corn, as a feedstock. For example, in 1980-81, DOE awarded loan guarantees to plants using corn for ethanol production in Louisiana (5), South Carolina (2), Tennessee (2), Mississippi (1), and Georgia (1) (U.S., DOE, Off. of Public Affairs, 1980; OGJ, 1981h). In total, these 11 plants are projected to produce approximately 533 million gallons (12.7 million barrels of ethanol) per year--most of it, 411 million gallons, would be produced by the five ethanol plants clustered in southeast Louisiana. These 11 ethanol plants would require approximately 205 million bushels of corn per year, 1.3 times the total corn production of these states in 1978. Moreover, while the plants in Louisiana alone would require 158 million bushels of corn, production of corn in that state is negligible. Thus, although plants in the South may use grain in the future to produce ethanol, they will need to "import" those grains from other states.

Sugar cane is another frequently mentioned feedstock for ethanol production. Again using Florida as an example, in 1977, 285,000 acres of sugar cane were harvested with a total yield of 8.5 million tons of sugar. It takes about 13 pounds of sugar to produce one gallon of ethanol; thus, Florida's total sugar cane crop had the potential for producing 131 million gallons of ethanol, or 2.6 percent of the state's current gasoline consumption (La Hart, 1981).

Not only would devoting Florida's sugar cane crop to ethanol production yield small returns in meeting the state's energy requirements, but distillation of cane juice yields 12.5 gallons of stillage per gallon of ethanol produced; disposal of this large volume of waste poses difficult environmental problems. Further, sugar cane has one of the highest nutrient requirements of any crop (Barnes, 1964). If Florida harvested its sugar cane on a sustained yield basis, it would require 6,800 tons of ammonia, 5,100 tons of phosphate and 12,750 tons of potash each year. These nutrients are extremely energy-intensive to produce, transport and apply to the crop, and they may contain as much energy as the cane produces.

6.7.4 Environmental Issues

Table 6-31 presents some of the environmental issues related to the production of alcohol fuels from biomass. The most significant environmental issues associated with silvicultural and agricultural biomass resources are likely to stem from the production and conversion phases rather than from the use of products. The amount of impact will vary and, to a large degree, be dependent on site-specific characteristics such as type of soil, climate, topography, impact control measures, and the technologies employed.

The environmental issues related to the production of biomass resources for energy generally are the same as those encountered when crops and forests are grown for other uses--for example, increased potential for soil erosion and degradation of water quality through siltation of streams and runoff of fertilizers and pesticides, leaching of excessive applications of fertilizers, etc., into ground water, depletion of nutrients and organic matter in the soil, reduction in ecosystem diversity, and increased blowing dust from loss of land cover. For further discussion of these and other issues related to the production of biomass see Chapter 9.

During the conversion of biomass into alcohol fuels, surface water resources could be contaminated by effluents from the conversion facilities. Liquid waste streams originate from many different process steps; a plant using corn for a feedstock, for example, to produce 50 million gallons of ethanol per year would

TABLE 6-31: SELECTED ENVIRONMENTAL ISSUES OF BIOMASS FUELS PRODUCTION

Production Stage	Water Quality	Air Quality	Land Use and Solid Waste	Safety and Health	Other
Feedstock Production	Nonpoint source water pollution (sedimentation, fertilizers, pesticides)-	Effects on worldwide CO_2 balance Fugitive dust from cropped areas	Large land areas required Land erosion from intensive cultivation	Occupational hazards with large-scale biomass harvesting Accident risks from biomass transportation	Increased water use for irrigation in water scarce areas of Texas, Oklahoma, and New Mexico Possible effects on food exports and balance of payments
Conversion	Potential water pollution from stillage disposal (BOD and COD) Toxic, liquid waste disposal from methanol production (tars, phenols, etc.)	Air emissions from fuels used to run ethanol process Air emissions from methanol production Emissions from direct burning of biomass (residential and industrial)		Explosions and fires in ethanol or methanol plants Toxic chemicals used in dehydrating ethanol Toxicity of methanol	Environmental regulation difficulties from many dispersed facilities Water requirements for ethanol conversion
End Use	Potential spills	Increased evaporative emissions from methanol fuels Changed automotive exhaust emissions Increase in some pollutants; decrease in others) Lower levels of air emissions with methanol substituted for coal, oil, or natural gas		Increased hazards from fuel vapors (esp. with methanol	Possible illegal and hazardous consumption of ethanol Important questions about net-energy efficiency of the entire process Methanol fuels require modifications to automobile fleet

CO_2 = carbon dioxide   BOD = biochemical oxygen demand   COD = chemical oxygen demand produce approximately 3.5 million gallons per day of wastewater. This water is acidic, high in total solids (25,000 pounds per day), suspended solids (3,000 pounds per day), and biochemical oxygen demand (BOD) (7,300 pounds per day) (Radian, 1979). Stillage is particularly high in BOD and mineral salts; both surface and ground water could be affected by improper or inadequate treatment or disposal (Collins et al., 1981).

The major air pollutants associated with the conversion of biomass to alcohol fuels stem from the combustion of fossil fuels, particularly coal, to provide process heat (see Section 6.4.4). Emissions from the direct burning of wood by relatively large industrial and utility facilities are not expected to present many air quality problems provided that combustion design, operation, and controls are appropriate (Dunwoody et al., 1980). The primary air pollution problem associated with increased wood combustion is the emission of hazardous compounds from uncontrolled residential sources, especially where the sources are highly concentrated. Uncontrolled burning releases organic compounds, NO_x, CO, particulates, and hydrocarbons. Recent research has shown that wood contains significant quantities of potentially carcinogenic mutagenic compounds (e.g., benzo(a)pyrene) that may be released during burning in residential units (D'Alessio and Kawaoka, 1980). Further, emissions from residential wood-burning stoves and fireplaces are not subject to air quality regulations.

6.8 PEAT AS AN ENERGY RESOURCE

6.8.1 Introduction

Peat is a geologically young coal consisting of partially carbonized remains of certain plants. Peat has long been used in Europe, the Scandinavian countries, and the Soviet Union as a source of fuel and chemicals. The peat resources in the United States are the third largest in the world and are estimated to contain about 1,440 quads (Q) of energy, the equivalent of 240 billion barrels of crude oil (Farnham, 1979).

In the past, U.S. peat has been virtually unexploited as an energy source due to the availability of other fuels at low cost. However, since 1975, interest in peat has grown in the U.S. and numerous studies have been conducted by private industry as well as by various state and federal agencies. Peat is attractive because it represents a considerable potential energy resource (second in recoverable reserves to coal), can be burned directly to produce heat or steam for electricity generation, or can be converted to substitute natural gas. Peat also is a relatively clean fuel, particularly compared to high sulfur coal, and is located in many regions where no other local energy resources are available (Radian, 1980).

Four of the top ten states in estimated peat reserves are in the Sunbelt--Florida, Louisiana, North Carolina, and Georgia. This section will discuss the distribution of peat in the Sunbelt, the current and future status of peat in the South, and the environmental issues associated with the harvesting, processing, conversion, and utilization of peat.

6.8.2 Resource Distribution

Peatlands exist throughout the world and are estimated to cover between one and two percent of the total surface area. In the United States, peatlands cover approximately 52.6 million acres. While detailed inventories are needed to describe accurately the U.S. peat reserves, it is thought that hemic peat is the most widely distributed and largest quantity peat-type in the U.S. The high density of fixed carbon and low ash content make hemic peat the most valuable of the peat types as an energy source (Fuchsman, 1978). The potential energy available from peat reserves is estimated at 1,443 Q, more than the combined proven reserves of western shale (430 Q), natural gas (249 Q), and petroleum (179 Q)(Williams Bros. Engineering, 1979).

Although peat is found in all 50 states, the major resource areas are in Alaska, the North Central region around the Great Lakes, and along the Atlantic Coast. The total U.S. peat reserves are estimated to be about 120 billion tons, with 51 percent of the peat located in Alaska (Table 6-32). Within the contiguous U.S., 90 percent of the resources are concentrated in ten states: Minnesota, Michigan, Florida, Wisconsin, Louisiana, North Carolina, Maine, New York, Georgia, and Indiana. The South contains about 13 percent (6.7 million acres) of the total U.S. peat lands and Florida, Louisiana, North Carolina and Georgia account for 96 percent of the South's share. The estimated 14.7 billion tons of peat reserves in these four states have the potential for producing approximately 176 quads of energy (Farnham, 1980).

The areas covered by peat deposits can be mapped fairly accurately; however, variations in depth and quality of peat are quite common between peatlands located in different geographical areas and even between bogs in the same area. Consequently, estimates of peat reserves are not as precise as other fuel reserve estimates; less than one percent of the peatlands have been surveyed in detail and the assumptions used may be questionable. Most estimates assume that the peat has a 35 percent moisture content, bulk density of 15 lbs/cu ft, caloric value equal to 6,000 Btu/lb, and an average depth of seven feet. Further, no distinction is made between fuel-grade peat and spagnum peat, which currently is not considered to be fuel-grade quality. Although a precise estimate of U.S. peat reserves is not yet available, they are believed to be significant enough to consider peat as an important energy alternative (Punwani, 1980).

TABLE 6-32: ESTIMATED U.S. PEAT RESERVES AND POTENTIAL ENERGY

	Estimated Reserves		
Geographic Area	Acres (millions)	Quantity (billion tons)	Potential Energy Available[a] Quads (10^{15} Btu)
Sunbelt			
Florida	3.00	6.9	82
Louisiana	1.80	4.1	49
North Carolina	1.20	2.7	33
Georgia	.43	1.0	12
Remaining lower 48 states	19.17	43.9	526
Alaska	27.00	61.7	741
Total	52.60	120.3	11,443

Source: Data from USDA, SCS, 1967.

[a] Assumes a 35 percent moisture content, bulk density of 15 lbs/cu ft, an average depth of seven feet, and a caloric content of 6,000 Btu/lb.

6.8.3 Current and Future Status

Peat can be used as a source of energy either by direct combustion or conversion to synthetic liquid and gaseous fuels. Until recently, peat could not compete with the cheaper and more readily available supplies of petroleum and natural gas. However, the vast peat resources of the U.S. are now being considered as a viable source of energy for several reasons (U.S., DOE, Div. of Fossil Fuel Processing, 1979):

- The U.S. has one of the world's largest reserves of peat;
- The majority of the reserves in the contiguous U.S. are located in regions that have virtually no other fossil fuel resource;

- Technologies for extraction and direct combustion to generate electricity are available from Europe;

- Technologies for the conversion of lignite and coal to substitute natural gas are being developed in the U.S. and could be used for gasification of peat;

- The chemical properties of peat make it a good feedstock for gasification processes; and

- There is a relatively large yield of liquids (benzene and other gasoline blends) from the hydrogasification of peat as compared to other coals.

With existing and continued development of new technologies it appears that peat could be used to produce sufficient amounts of substitute natural gas, synthetic liquids, and electricity to meet limited regional requirements. In those areas that are rich in fuel-grade peat, electricity from peat-fired power plants could reduce dependency on oil, help meet future power needs, potentially reduce SO_x emissions, and use in-state energy resources (King et al., 1980).

Even though peatlands occur worldwide, only a few countries have developed peat as an energy source (e.g., U.S.S.R. and Ireland). Although no peat resources in the United States currently are used for energy production, programs are being developed in an attempt to determine the feasibility of using peat as an energy source. One of the two nonfederal programs, First Colony Farms, is located in North Carolina. Florida and Louisiana are other Sunbelt states that have significant deposits of peat and the potential for development.

A. North Carolina[1]

The major peatlands of North Carolina are found along the coastal plain and were formed from organic materials derived from trees, shrubs, and other herbaceous materials associated with a coastal marsh and woodland complex (Figure 6-9). The deposits are extensive and appear to have favorable fuel-grade qualities-the peats are highly decomposed, have a caloric value from 7,000 to 10,000 Btu/lb, and low sulfur and ash content.

Currently, there is extensive use of the peatlands for agriculture and forests. However, First Colony Farms (a private corporation) is attempting to develop the peat resources for use in energy production. It owns approximately 146,000 acres of farm

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[1] The profiles of North Carolina, Florida, and Louisiana are based, in large part, on King et al., 1980.

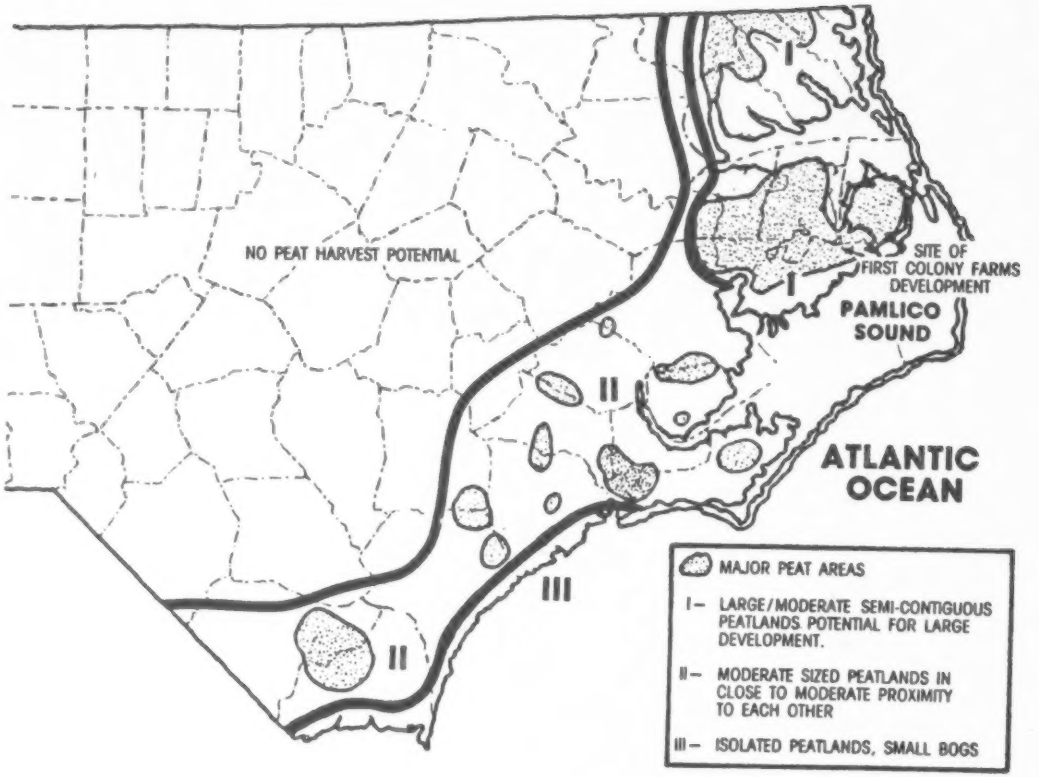
I
SITE OF
FIRST COLONY FARMS
DEVELOPMENT
PAMLICO
SOUND
NO PEAT HARVEST POTENTIAL
II
ATLANTIC
OCEAN
III
II
MAJOR PEAT AREAS
I– LARGE/MODERATE SEMI-CONTIGUOUS PEATLANDS POTENTIAL FOR LARGE DEVELOPMENT.
II– MODERATE SIZED PEATLANDS IN CLOSE TO MODERATE PROXIMITY TO EACH OTHER
III– ISOLATED PEATLANDS, SMALL BOGS

Figure 6-9: North Carolina Peat Resource Areas

Source: King et al., 1980, p. 4-38.

property with peat reserves ranging from two to eight feet in depth. The company plans to use an estimated 407 million tons of peat to supply energy to North Carolina over the next several decades (U.S., DOE, Div. of Fossil Fuel Processing, 1979).

First Colony Farms has been involved in a variety of studies since 1974 including the feasibility of direct combustion of its low-sulfur peat to produce electrical energy, peat gasification experiments, and the possibility of blending peat with fuel oil to reduce the cost of fuel for drying kilns. Its current development plan is to construct a large-scale peat harvesting system to supply a 150 MW electrical power plant. Long range plans call for peat to fuel a 600 MW power plant to be located at First Colony Farms. The state of North Carolina has requested that First Colony Farms prepare an environmental impact assessment on their developments. Saltwater intrusion and estuarine impacts from large scale coastal agricultural development already have been noted and the potential environmental impacts from peat development on the estuarine ecosystems are considered to be the prime environmental issue.

B. Florida

Peatlands cover a large portion of Florida--approximately three million of the state's 34.6 million acres. The major peat deposits are found in the Everglades south of Lake Okeechobee (Figure 6-10). This area contains extensive agricultural developments, unmanaged lands, and the Everglades National Park. In addition, the peatlands form a surface aquifer that is important to the water supply for the park.

The high quality of south Florida's rich muck soil requires less energy intensive agricultural practices and has resulted in the use of a substantial portion of the peatlands for agriculture. However, draining of peatlands for agriculture has resulted in subsidence of about one inch per year, primarily from oxidation of the upper layers. Because this has resulted in a net reduction in agricultural productivity, the large agricultural industry within the state would be expected to promote increased agricultural production from any new lands that are allowed to be developed. It is not clear what perspective would be taken by the state concerning energy developments as a competing use of the peatlands.

The peat resources within the southern portion of the state could support a large-scale peat facility, but such a development could have significant impact on the Everglades and other areas downslope of the project. Even though there is no regulation against the use of peat as a fuel, federal agencies and environmental groups have offered strong resistance to further development of the state's wetlands and would likely oppose the large-scale harvesting of peat. In addition, Florida has very strong

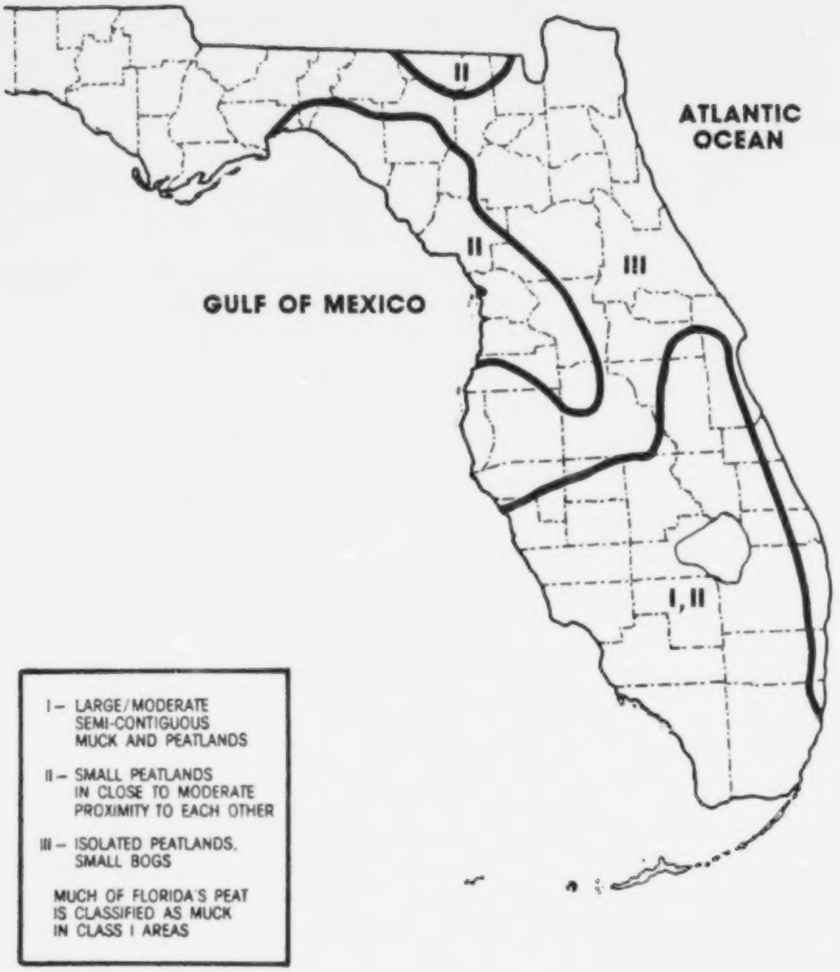
II
ATLANTIC OCEAN
II
III
GULF OF MEXICO
I, II
I – LARGE/MODERATE SEMI-CONTIGUOUS MUCK AND PEATLANDS
II – SMALL PEATLANDS IN CLOSE TO MODERATE PROXIMITY TO EACH OTHER
III – ISOLATED PEATLANDS, SMALL BOGS
MUCH OF FLORIDA'S PEAT IS CLASSIFIED AS MUCK IN CLASS I AREAS

Figure 6-10: Florida Peat Resource Areas

Source: King *et al*., 1980, p. 4-47.

energy siting regulations that require consideration of regional impacts on water resources and wetlands.

Extensive agricultural development (e.g., in Dade county) already has led to the eutrophication of numerous lakes, loss of organic soil, and reduction in the water table. Peat harvesting for energy production could make these problems worse, cause greater saltwater intrusion, and alter sensitive ecosystems that provide habitat for many endangered and threatened species. Thus, while Florida has substantial peat resources, a variety of factors could limit the energy developments from some of the most attractive deposits.

C. Louisiana

The amount of peat in Louisiana has not been well documented, but the resources have been estimated to cover about 1.8 million acres. The majority of the peatlands are confined to the low-lying coastal wetlands, the Mississippi Delta area, and the Atchafalaya Floodway (Figure 6-11). The quality of peat is highly variable due to the periodic inundation of the peatlands from freshwater and hurricane flooding and the incorporation of sediments, clays, silts, and other organic debris with the peat. Studies to better define the state's peat resources have been undertaken by the Louisiana Geological Survey and the Coastal Studies Institute of Louisiana State University.

Unlike other states with significant peat resources, Louisiana is accustomed to large energy development projects and has a history of supporting such projects. However, the development of peatlands for energy production could be constrained by a number of factors. For example, the state is a net exporter of energy and the benefits of developing the peat resources may not be viewed as outweighing the costs. Further, the peat deposits occur in areas that constitute some of the most valuable and sensitive environmental areas within the state; large tracts of peatlands are in or adjacent to state and national wildlife refuges. Energy development within these areas historically has been for oil and gas recovery, hydrocarbon storage, and transport corridors; no large surface exploitation has taken place. Peat harvesting could add to the environmental problems already present from current energy developments.

Wetlands protection in Louisiana is very important because of the intrinsic value of the ecosystem and the commercial value derived from the fish and shellfish industry. Because of the inevitable loss of wetland habitat and the potential for producing offsite impacts, any moderate- to large-scale peat development program will require strategies for assuring maintenance of the fish and shellfish resources.

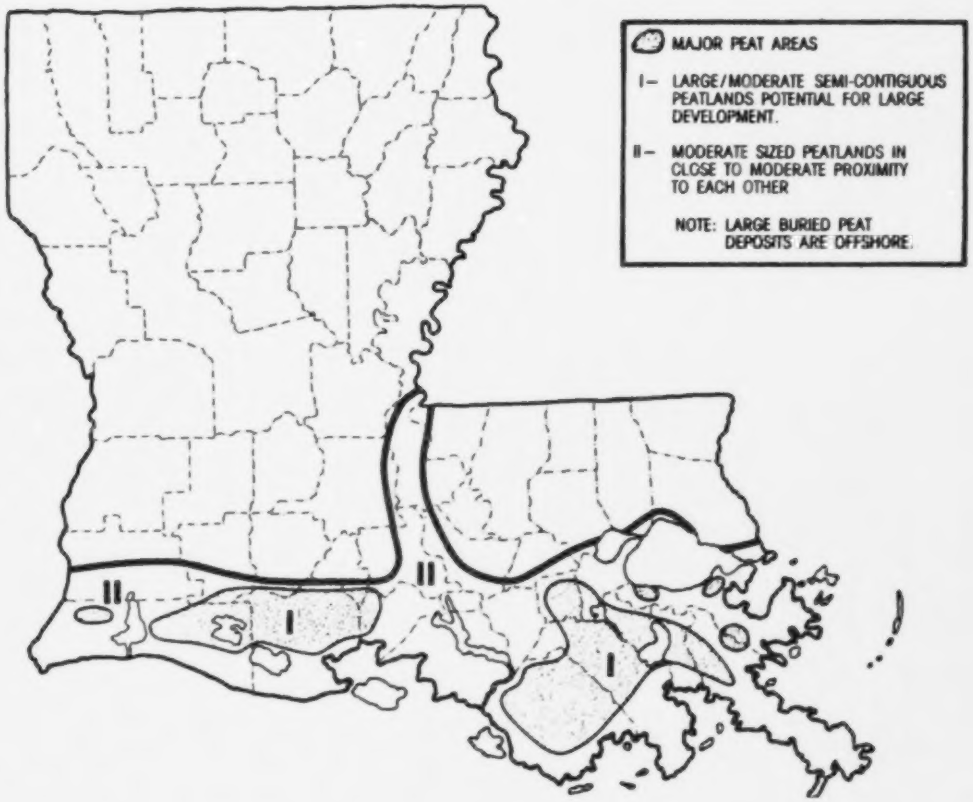
MAJOR PEAT AREAS
I– LARGE/MODERATE SEMI-CONTIGUOUS PEATLANDS POTENTIAL FOR LARGE DEVELOPMENT.
II– MODERATE SIZED PEATLANDS IN CLOSE TO MODERATE PROXIMITY TO EACH OTHER
NOTE: LARGE BURIED PEAT DEPOSITS ARE OFFSHORE.
I
I
II
II

Figure 6-11: Louisiana Peat Resource Areas

Source: King et al., 1980, p. 4-53.

6.8.4 Environmental Issues

As noted in Table 6-33, a wide range of environmental issues is associated with the development and utilization of peat as a source of energy. The most significant potential environmental issues are likely to be related to harvesting and preparation and to the conversion of peat into energy--either through direct combustion or through the production of synthetic fuels.

The nature and degree of potential air quality impacts depends on the particular technologies used in the various phases of the peat utilization process. Air quality in peat-rich areas typically is better than for many other areas and significant local air quality degradation could result from harvesting, handling, and storage activities. Dust from wind-blown dry peat is the major potential pollutant associated with these activities and could be very difficult to control if the milled peat harvesting method is used (Williams Bros. Engineering, 1979). Direct combustion of peat could increase the total suspended particulate concentration of the surrounding area. Further, although peat typically contains far less sulfur than older coals, it can contain significant concentrations of heavy metals. The more volatile of these heavy metals could be released to the atmosphere during direct combustion if emission controls are not adequate. Heavy metals would not be a problem in the synthetic fuels produced from peat (e.g., through gasification); however, they would be concentrated in waste sludges which could lead to disposal problems (U.S., DOE, Div. of Fossil Fuel Processing, 1979).

Because of the close relationship between peat bogs and water, the development of peat resources has the potential for severe impacts on surrounding water resources, in terms of both quantity and quality. In development projects that will require the bog to be drained, the overall hydrologic balance of the area will be shifted and the removal of the peat could permanently disrupt the location of local water tables. Also, a water quantity impact will likely result from the requirements of the energy production facilities (steam-electric and peat gasification plants) associated with the peat development.

Peatland development will require the discharge of water from bog draining and wastewater from energy processing activities. The discharge of these waters to other water sources could significantly change the character of the receiving waters. These changes could affect the downstream aquatic and estuarine ecosystems and could potentially limit downstream water uses (King et al., 1980). Because of the characteristics of the drainage and process waters, inadequate controls or accidental releases could reduce the pH of the receiving stream, create oxygen deficiencies due to high BOD and COD, increase eutrophication from high nutrient levels, and introduce potentially toxic levels of heavy metals into the receiving stream.

TABLE 6-33: SELECTED ENVIRONMENTAL ISSUES OF PEAT DEVELOPMENT

Production Stage	Water Quality	Air Quality	Land Use and Solid Waste	Safety and Health
Harvesting and Preparation	Alteration of wetland hydrogoloy Saltwater intrusion Increased organic loading	Dust	Destruction or modification of bogs and wetlands Habitat fragmentation	Hazards from operation of harvesting equipment
Conversion	Thermal discharges Organic and inorganic waste discharges	Emissions of criteria pollutants Contribution to greenhouse effect	Habitat fragmentation Disposal of process wastes	Potential exposure to carcinogens in some processes
End Use	Potential spills	Potentially increased hydrocarbon emissions from some liquid fuels Contribution to greenhouse effect		Contamination from product spills

The activities associated with peat harvesting, in combination with the transition of the peatlands from a natural habitat to an unknown condition, could generate physical and chemical changes that would affect the aquatic and estuarine ecosystems, destroy natural vegetation and eliminate wildlife habitat (Moore and Bellamy, 1975; King et al., 1980). For example, preliminary studies conducted to identify aquatic habitats and populations particularly affected by peat development in North Carolina have indicated detrimental consequences from changes in water quality. The expected impacts of peat harvesting on the riverine areas and sounds of the coastal zone include degradation of sport and commercial fisheries, more frequent kills, and continual recurrence of fish disease outbreaks. Some displacement of saltwater species could occur due to increased runoff from the peatlands. Peat mining adjacent to lakes is expected to drop water levels, reduce water quality, and potentially reduce certain fish populations (Kornegay, 1981). In addition, since the peat harvesting process involves the complete removal of all existing forest and shrub vegetation, habitat for certain terrestrial species would be eliminated (Critcher, 1981).

Many of the potential negative impacts of peat development could be mitigated through proper harvesting techniques, drainage control, and careful choice of land reclamation options. However, if the important environmental issues are not satisfactorily resolved, peat utilization could be severely constrained in the Sunbelt.

6.9 GEOTHERMAL ENERGY RESOURCES

6.9.1 Introduction

The potential for geothermal energy stems from the enormous heat contained in the 260 billion cubic miles of rock at or near its melting point just below the earth's crust. Geothermal heat can be recovered from hydrothermal reservoirs, geopressured zones, and from rock in areas where the geothermal gradient is higher than normal. Heat from these resources can be used directly (e.g., heat for homes and greenhouses, drying crops and wood, industrial processes), or converted to electrical or mechanical energy. Given current technologies, only a very small portion of this thermal energy can be economically utilized.

To date, the Geysers in California (800 MW from natural steam) is the only commercial application of geothermal resources for electricity generation in the U.S. The Sunbelt, particularly Texas, Louisiana, New Mexico, and selected areas along the Atlantic Coast, contain all three types of geothermal resources. While geothermal resources are not likely to add significantly to overall energy production in the South, they can contribute to the energy available at the local level. This section will discuss the potential for development of geothermal resources in the Sunbelt, current and projected activities, and the environmental issues of geothermal energy development.

6.9.2 Current and Future Status

As described in Table 6-34, the goals for geothermal energy production in the year 2000 include electricity production equivalent to 2.2 quads of fossil fuel input, direct heat use equivalent to one quad, and methane production of three quads (IGCC, 1980). These goals assume an aggressive federal program

TABLE 6-34: NATIONAL GEOTHERMAL UTILIZATION GOALS (quads/year)

Resource Type	1985	1990	2000
Hydrothermal			
Electric Applications	0.24	0.6	2.0
Direct Thermal Applications	0.1	0.2	1.0
Geopressured			
Electric Applications	0.001	0.006	0.16
Direct Thermal Applications[a]	-	-	-
Methane[c]	0.02	0.1	3.0
Hot Dry Rock (Estimates Only)[b]			
Electric Aplications	0.001	0.003	0.06
Direct Thermal Applications	0.001	0.001	0.007
Total (rounded)	0.4	0.9	6.2

Source: Adapted from IGCC, 1980, p. 11.

[a] As yet, the markets for nonelectric applications of geopressured energy sources are not well enough defined to establish meaningful objectives.

[b] These are not yet set as goals; only estimates of production are possible at this time.

[c] These values are highly variable due to the lack of information concerning the amount of methane contained in the brine.

and major involvement on the part of the private sector. In the late 1970's federal and private support for geothermal development was strong and growing. More recently, federal support has been curtailed and it is not yet clear how the private sector will react to this cutback. Consequently, estimates of future use of geothermal resources are tenuous at best. However, some states in the South, particularly Texas, are moving ahead with the formulation of geothermal research and development plans.

A. Hydrothermal Reservoirs

Hydrothermal systems include steam and hot water trapped in fractured rocks or permeable sediments by impermeable surface layers. A hydrothermal system is classified as either water- or vapor-dominated according to the principal physical state of the fluid. While little potential exists for the development of vapor-dominated reservoirs within the South, exploration and development of water dominated reservoirs is possible.

Molten or recently solidified rock at depths of 15,000 to 35,000 feet supplies the heat for hot water reservoirs. Water circulates throughout the reservoir and removes heat from the deep hot rock by convection. The temperature of the water is nearly uniform and can reach 350°C and higher.

At present, no commercial electricity is produced in the U.S. from hot water geothermal sources. A number of demonstration projects are underway, however. In May 1980, construction began on a facility at Valles Caldera, New Mexico, which will be the nation's first commercial scale demonstration plant (50 MW) using hot water to produce electricity. Test wells at the Valles Caldera facility indicate a reservoir capable of supporting 400 MW of electricity generation. Operation is expected to begin in 1983.

As can be seen from Figure 6-12, the South has a much greater potential for the development of low to moderate temperature resources for uses such as direct heating, than for the production of electricity from high temperature reservoirs. For example, six areas of potential hydrothermal resources have been identified along the Atlantic Coastal Plain: Savannah-Brunswick, Georgia; Charleston and Georgetown, South Carolina; and Wilmington, Kinston, and Eastern Shore, North Carolina. By the mid 1990's, these areas are expected to produce about 0.1 quad of energy per year for consumption by the private, commercial, and industrial sectors (Toth and Paddison, 1977).

In central and southern Arkansas, hydrothermal resources are projected to produce about 74 milliquads per year to be used for residential and commercial space heating, hot water, and industrial processes (Fox, 1977). Hot water has been used for a number of years to heat greenhouses in Lordsberg, New Mexico.

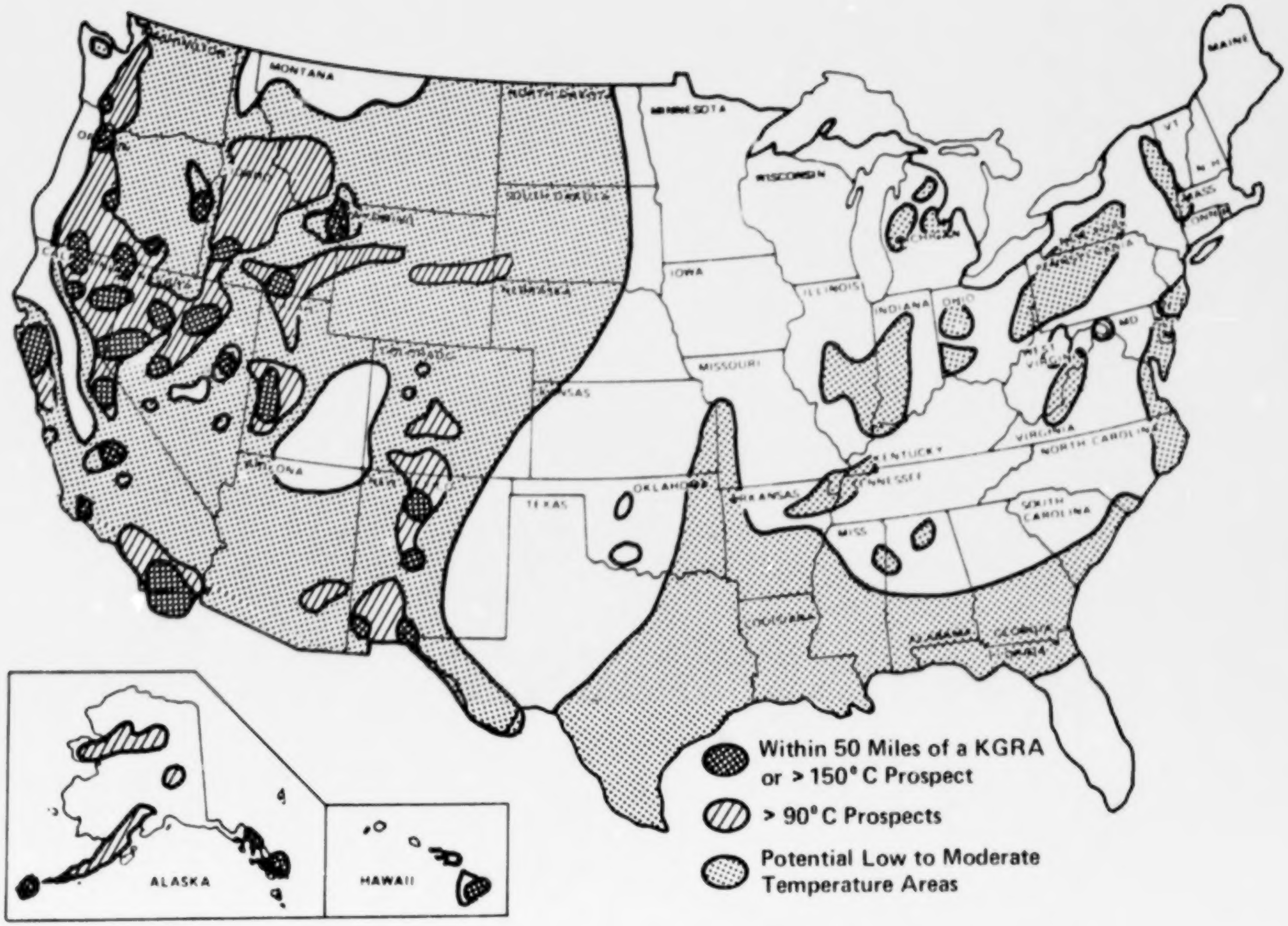

Figure 6-12: Known and Potential Hydrothermal Resources

Source: IGCC, 1980, p. 20.

The central Texas area (Figure 6-13) has been the most active geothermal resource region in Texas. For example, a high school in Cotulla was designed and built to facilitate use of heat energy from a warm water well drilled on the school grounds. A geothermal space heating demonstration system currently is under construction at a hospital in Marlin, Texas and is expected to displace approximately 84 percent of the hospital's average annual natural gas consumption (Davis et al., 1981). The New Mexico Energy Institute (1980) has estimated that by the year 2000, 0.25 quads per year of geothermal energy will be supplied from the Central Texas resource region. This could affect 357 cities with a total population of 4.5 million people.

B. Geopressured Zones

Geopressured zones consist of water at higher than normal temperatures and pressures trapped in aquifers sealed between impermeable layers of clay and shale. The deep sedimentary basins of the Texas and Louisiana Gulf coasts are underlain by thick beds of water-filled sandstones and contain the principal geopressured zones in the U.S. (Sacarto, 1976). These formations underlie an offshore band at least 100 miles wide and about 750 miles long, with an equal area onshore (Westhusing, 1980).

The geothermal reservoirs along the Gulf coast have two characteristics generally not found in other geothermal formations. The Gulf Coast reservoirs have unusually high pressures (5,000 to 13,000 pounds per square inch) due to the weight of the overlying sediments (House, Johnson, and Towse 1975). Further, the brine generally is saturated with natural gas (methane), an important supplement to energy production. Studies have indicated that approximately 30 to 45 cubic feet of gas may be dissolved in each barrel of water (McNamara and Kaufman, 1979); however, test wells have produced 20 to 50 cubic feet per barrel.

The geopressured resources along the Texas and Louisiana coasts are especially attractive because three types of energy could be produced: electrical (from high temperature fluids), mechanical or hydraulic (from the high pressure), and chemical (from the natural gas). While not much electricity production is expected, other potential uses for geopressured resources include: Frasch technique for sulfur production, process heat application, coal desulfurization and preparation, lumber and concrete products kilning, hydroponics greenhousing, grain drying, and space heating and cooling (RPC, 1979).

Development of geopressured zones currently is at the exploratory, resource-assessment stage. Further, a number of uncertainties exist with respect to the recoverability of the energy contained in geopressured zones including: (1) the size of the potential resource; (2) feasibility and economics of resource

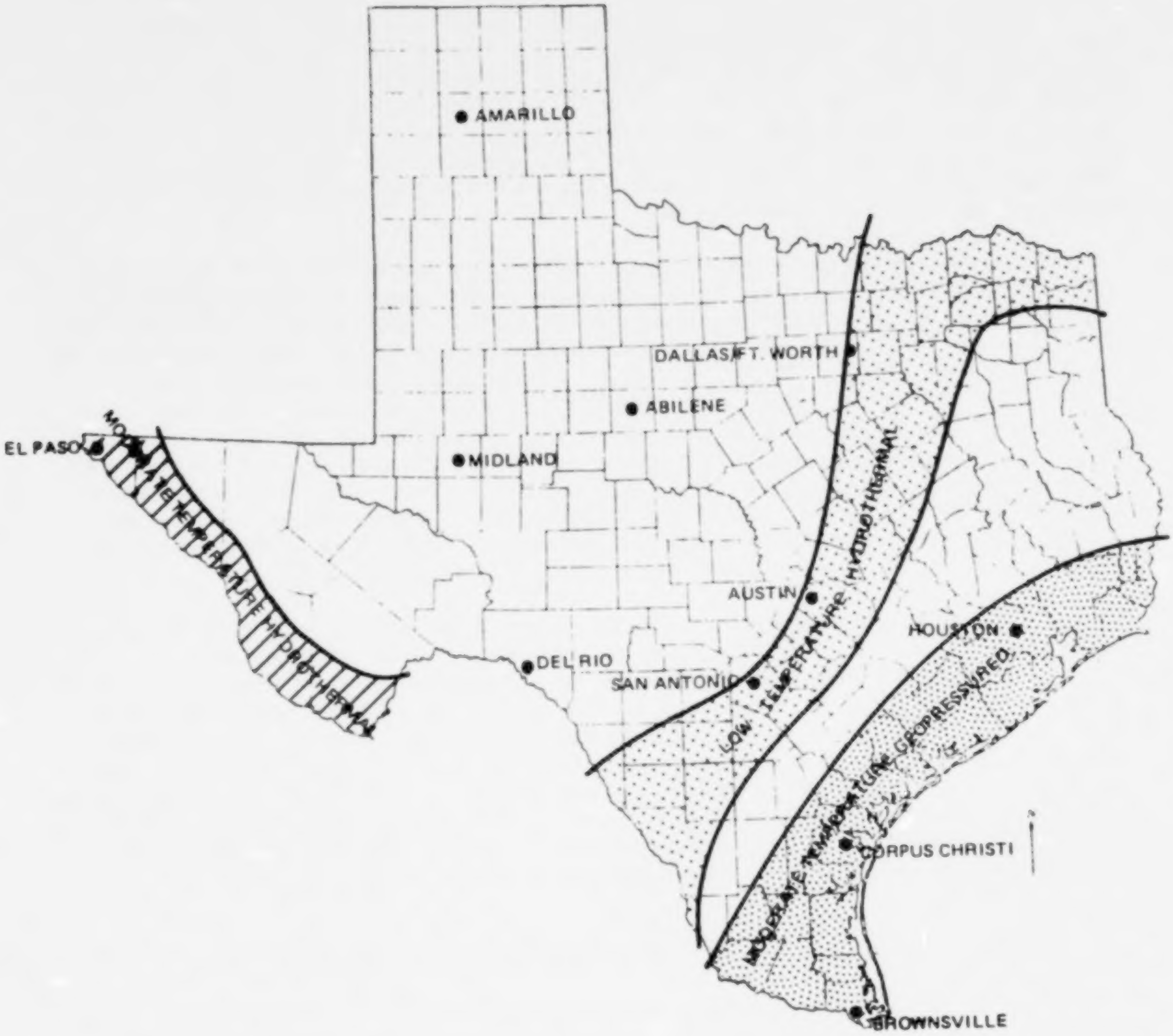

Figure 6-13: Texas Geothermal Resource Regions

Source: Texas Energy and Natural Resources Advisory Council, n.d.

recovery; and (3) the magnitude and cost of environmental considerations (Westhusing, 1980).

As evident from the estimates displayed in Table 6-35, projections concerning energy resources in the Gulf Coast geopressured zone are highly variable. Compared to more recent estimates, early estimates were extremely high. For example, in 1975 the USGS estimated the energy available from dissolved methane to be about 24,000 quads, with an additional 43,000 quads from thermal energy, and mechanical energy equivalent to 198 quads. The USGS has since revised its estimates for methane (3,220 quads) and thermal resources (5,800 quads) to include only the most favorable onshore sandstone reservoirs.

The uncertainties associated with the geopressured resource lead to wide variations in estimates even when considering recoverable energy. Recent estimates of total recoverable methane vary from 50 to 5,000 quads due to uncertainties about the salinity of pore fluids (Davis et al., 1981). A study conducted by the Southwest Research Institute (SWRI) challenges even the most recent estimates and concludes that the production of natural gas and thermal energy from the 20 most favorable areas of Texas and Louisiana may be only a fraction of what once was thought recoverable (OGJ, 1981i). SWRI estimates the recoverable dissolved methane from known geopressured zones at only 7.6 quads with an additional 12.6 quads from potential thermal energy.

While disagreements continue about the amount of energy available from the geopressured zones in the South, the potential energy resources do not appear to be as great as once thought. However, exploration is continuing in order to define the resource and locate the most favorable sites for development. Fourteen areas onshore in Texas have been identified as geopressured fairways and drilling of test wells has begun. Exploration activities also are taking place in Louisiana by drilling new wells and using wells of opportunity--nonproductive oil and gas wells which approach or penetrate the geopressured zone.

C. Hot Dry Rock and Normal-Gradient Geothermal Heat

As the upper portion of the earth's crust is penetrated from the surface, the temperature normally increases about 30°C per kilometer (C/km), i.e., the normal geothermal gradient. Higher than normal geothermal gradients (at least 40°C/km) are often encountered where the earth's crust is thin or has recently been disturbed by volcanism or faulting. This offers the possibility of reaching higher temperature hot dry rock with a shallower, less expensive well. The cost advantage of these shallower wells is sufficiently great so that a distinction commonly is made between hot dry rock and the normal gradient.

TABLE 6-35: ESTIMATES OF TOTAL GEOPRESSURED RESOURCE, ONSHORE/OFFSHORE THE TEXAS-LOUISIANA GULF COAST (in quads)

Source	Thermal	Mechanical	Gas	Total
Brown-Hudson (1976)	--	--	60,000	60,000
Dorfman-Texas (1978)	--	--	5,735	5,735
Hawkins-LSU (1977) (Louisiana Only)[a]	19.5	1.2	13.6	34.3
Jones-LSU (1976) (Sands and Shales)	--	--	100,000	100,000
Hise-LSU (1977)	--	--	3,000	3,000
Papadopulos-USGS Circ. 726 (1976) (Sands and Shales Assessed Onshore Only)	43,331	198.0	23,927	67,456
Lewin & Associates	--	--	1,100	1,100
Wallace-USGS Circ. 790 (1978)				
(Assessed Onshore Sandstone Only)	5,800	--	3,220	9,100
(Assessed Offshore Sandstone Only)	5,200	--	2,800	8,000
Bernard (1978)[a]	--	--	54	54
EPRI-SWRI (1980)[a]	12.6	--	7.6	20.2
Gregory *et al.*-BEG (1980) (Onshore Sandstone, Texas Only)	--	--	688.9	688.9
National Petroleum Council (1980)[a]	--	--	81	81

Source: Gregory *et al.*, 1980; SWRI, 1980; U.S., DOE, Div. of Geothermal Energy, 1979, 1980.

[a] Only recoverable amounts calculated.

Extracting heat from hot dry rock is accomplished by injecting cool water through one drill hole, allowing it to circulate until it reaches a hot enough temperature, and then recovering it as steam or hot water. The main technical barrier is the lack of a method for artificially creating a large permeable region through which the water can circulate before it is withdrawn and used.

Within the South, New Mexico appears to have the greatest potential for the development of hot dry rock resources. The feasibility of using fluid pressure to create a fracture system connecting two well bores has been demonstrated at Fenton Hill in northcentral New Mexico (NRC, CONAES, 1979). The well was drilled to 3,050 meters (10,000 ft) with a bottomhole temperature of 205°C. The test facility has been in operation since 1977 and it is the first time electricity (6 MW) has been produced from hot dry rock (Energy Insider, 1980). A second system drilled to 15,000 feet is designed to produce between 20 and 50 MW of thermal heat that can be converted into 3 to 10 MW of electric power. Testing of the facility is scheduled for 1988 (BNA, 1980b). While hot dry rock resources may be important on a localized basis, their use will not be widespread or important to the Sunbelt as a whole.

It appears likely that the technical and economic questions will be resolved within the next few years and an experimental project to use hot dry rock resources on a commercial scale will prove feasible by the end of the 1980's (IGCC, 1980). Presumably, the techniques used to extract heat from hot dry rocks could be extended to greater depths when and if it becomes economical to use heat from normal-gradient resources.

6.9.3 Environmental Issues

Table 6-36 summarizes some of the environmental issues associated with geothermal energy production. The major constraints to geothermal development in the South include airborne emissions, brine disposal, subsidence due to production of high volumes of fluid, and the potential for induced seismicity.

When water or steam is used in hydrothermal systems, noncondensable gases such as ammonia, boron, and hydrogen sulfide (H_2S) may result in environmental problems. For example, H_2S is present in 20 to 25 percent of all hydrothermal resource systems (Whitaker, 1980). Geopressured well tests have indicated that concentrations of noncondensable gases, except for ammonia, were quite low compared to hydrothermal systems. However, experience with natural gas wells suggests that H_2S levels could vary significantly and potential problems would be site specific (U.S., DOE, Asst. Sec. for Energy Technology and Asst. Sec. for Environment, 1979). While H_2S emissions are not likely to cause significant

TABLE 6-36: SELECTED ENVIRONMENTAL ISSUES OF GEOTHERMAL DEVELOPMENT

Production Stage	Water Quality	Air Quality	Land Use and Solid Waste	Safety and Health	Other
Exploration and drilling	Potential aquifer contamination Brine disposal		Mud disposal Ecosystem disruption from well drilling activities	Accidents and blowout risks	Induced seismicity Local noise disturbance
Steam or heat production	Potential thermal discharges Potential minerals discharge Brine disposal requirements Ground water contamination	Particulates and sulfur compound emission (H_2S) Minor radon releases Odor	Potential sludge disposal Subsidence	Steam hazards	Local noise disturbance
Electricity generation	Thermal discharge	Thermal release Some sulfur compound releases during steam venting (H_2S)		Steam hazards	Local noise disturbance Potential makeup water requirement

ecological or health effects, its odor presents a major nuisance (U.S., DOE, 1978.)

The disposal of spent geopressured fluids (brine) is one of the most significant environmental concerns. These fluids are high in total dissolved solids (1,000 to 10,000 parts per million [ppm]) and boron concentrations (20 to 60 ppm). Because of the great depths and pressures involved, it may not be economically feasible to inject the fluids back into the original reservoir. Possible options for disposal include discharge into existing saline bodies of water, injection into subsurface saline aquifers, and disposal to surface water such as the Gulf of Mexico. Each is feasible but with its own set of environmental risks (U.S., DOE, Asst. Sec. for Energy Technology and Asst. Sec. for Environment, 1979). Further, geothermal brines could be discharged accidentally at the surface due to well blowouts, pipeline leaks or breaks, failure at storage facilities, and through accidents in the gas separation and power generation facilities. Well blowouts are the most unpredictable and potentially are of the greatest magnitude. Projected well flow rates range from 40,000 to 128,000 barrels of brine per day. A blowout could remain out of control for months, releasing 4 to 16 acre-feet of brine per day (RPC, 1979).

Surface and ground water pollution resulting from the disposal of excess steam condensate and water is also a problem for hydrothermal systems. The hotter reservoirs have a higher salt content which requires reinjection rather than discharge into surface waters. These saline fluids will require treatment prior to reinjection in order to reduce the high maintenance costs associated with scaling, precipitation, and plugging. This leads to the need to dispose of large volumes of sludge which could result in surface and ground water contamination if sludge disposal is inadequate (U.S., DOE, Off. of Environmental Assessments, 1981).

The possibility of subsidence is another potentially serious consequence of the development of hydrothermal and geopressured resources. The withdrawal of large volumes of liquid from the geopressured reservoirs could cause the compaction of the reservoir strata, resulting in land subsidence. This could be an especially serious problem along the Gulf Coast since large areas of land are only a few feet above sea level and flooding could result (U.S., DOE, Asst. Sec. for Energy Technology and Asst. Sec. for Environment, 1979).

The relatively cooler hydrothermal reservoirs need to withdraw large volumes of water to produce a given amount of heat. This could result in subsidence and disruption of the aquifer. While injection of spent fluids back into the reservoir may aid in waste disposal and lessen the subsidence problem, the impact of reinjection is uncertain. It is possible that uplifting may occur around the injection wells while subsidence occurs in the area of the production wells.

The withdrawal and reinjection of geothermal fluids may increase the rate of seismic events. Many of the potential areas for hydrothermal development are located in regions with a high frequency of naturally occurring seismic events. On the other hand, the Gulf Coast generally is considered to be an aseismic region. However, Atherton et al. (1976, Vol. 2) reported earthquake events in the coastal areas of Texas and Louisiana that possibly were associated with oil and gas production. The principal causes of these events, which may be of importance in the development of geopressured resources, are thought to be the production of geopressured fluids and reinjection of spent fluids (U.S., DOE, Off. of Environmental Assessments, 1981).

In summary the use of geothermal resources could be important at the local level in many areas of the South. However, the development of these resources is dependent, in part, on solutions to the constraints imposed by H_2S emissions, fluid disposal, land subsidence, and seismicity.

6.10 SUMMARY

It is not possible to precisely predict the energy future of the Sunbelt and this chapter is not an attempt to do so. Rather, the information presented describes the current status of energy consumption and production in the South, expected consumption and production trends, and the environmental issues associated with current and potential energy developments.

Not only is the Sunbelt expected to continue its growth in population and economic development, but there is also little doubt that the southern regions will continue to play a key role in the nation's energy future. In 1979, the Sunbelt states produced approximately 60 percent of the nation's crude oil, 82 percent of the natural gas liquids, 87 percent of the natural gas, and 29 percent of the coal. On the other hand, the South accounted for about 28 percent of the total U.S. crude oil consumption, 47 percent of the natural gas consumption, and 25 percent of the coal consumption. Thus, even though the Sunbelt is very diverse and includes both energy producing and consuming states, overall the Sunbelt is an energy exporting region and is likely to remain so for the foreseeable future.

The South's energy resources are not infinite and the percentage of total U.S. energy resources supplied by the South is expected to continue to decline over the next 20 to 30 years. This is due, in large part, to the maturing of the South's oil and natural gas fields and the expansion of production of resources from other regions--for example, western coal and Alaskan oil. Although petroleum and natural gas production in the Sunbelt is expected to decline, enhanced recovery techniques and production from unexplored areas and from unconventional sources could stabilize production and possibly lead to increases in production. Unprecendented exploration and development activities are taking place throughout the Sunbelt--in the Gulf Coast areas of Alabama, Florida, and Mississippi; along the Eastern Overthrust Belt, in the Anadarko Basin of western Oklahoma and the Texas panhandle; and in the Tuscaloosa Trend region of Louisiana.

A key component of federal energy policy is a shift away from the use of oil and natural gas and a rapid increase in the use of coal. The Sunbelt contains about 26.5 billion tons of recoverable coal reserves and accounts for 29 percent of the total U.S. coal production. Although the proportion of U.S. production from the Sunbelt is expected to decline slightly over the next 20 years, absolute tonnage produced is projected to increase by 65 percent--from 240 million tons to 396 million tons. Kentucky, Texas and New Mexico are expected to account for approximately 88 percent of the coal mined in the Sunbelt in the year 2000.

Nuclear power also is a major source of energy for some parts of the Sunbelt. Uncertainty about future energy demands, substantial public opposition, rising construction costs, and new regulatory requirements following Three Mile Island have lead to a cautious wait-and-see attitude for many utility planners. However, the slowdown in construction of nuclear power plants in the southeast portion of the Sunbelt has not taken place to the same degree as in other regions of the country. Alabama, Florida, South Carolina, North Carolina, Georgia, and Tennessee account for 27 percent of the operating units and 31 percent of the total U.S. nuclear generating capacity. Nuclear power will continue to be important to Region 4, particularly in the Tennessee Valley Authority area and in the Carolinas. All new power generating capacity coming on line for the TVA region over the next ten years will come from nuclear power. Although nuclear power is not expected to play a major role as a source of energy in Region 6, northwest New Mexico and southcentral Texas are important uranium mining and milling centers. In addition, the salt domes of the Texas and Louisiana Gulf Coast are being considered as storage sites for high level radioactive wastes.

Other energy developments taking place in the Sunbelt are not expected to contribute significantly to national or regional energy supplies in the near future. However, locally important developments are likely to take place. For example, in the Sunbelt, the production of synthetic fuels from coal is expected to center around the coal fields of Kentucky and the lignite belt of Texas. Over half of the proposed or planned synthetic fuels from coal projects in the Sunbelt are concentrated in Kentucky and along the Texas and Louisiana Gulf Coast. The Devonian shale resources in Kentucky and Tennessee are under development as a source of oil. The forests and prime cropland of Region 4 make it the most likely area for the development of biomass resources for energy. The use of peat as a source of energy will probably be confined to North Carolina and possibly Florida and Louisiana. The development of geothermal resources is underway in New Mexico, along the Texas/Louisiana Gulf Coast, and in scattered locations along the coasts of Georgia and North and South Carolina. However, the large scale development of these various energy resources is surrounded by a great deal of uncertainty.

The potential environmental impacts associated with energy developments in the Sunbelt are varied and extensive. The extent of some future energy developments could be constrained by attempts to balance these developments with efforts to protect the environment. This particularly could be a problem in those areas likely to experience multiple energy developments. For example, Kentucky and the Gulf Coast of Texas could be impacted by increased coal mining, synthetic fuel production from coal, oil and gas exploration and production, additional coal-fired power plants, and conversion of biomass to liquid fuels. In addition, the Gulf Coast area has the potential for the development of geothermal resources and Kentucky could experience the development of its oil shale resources. The individual air, water, and land impacts of any one or two of these developments might be manageable. However, frequently the potential cumulative impacts of the range of possible energy developments in an area are not fully considered. The effects of these multiple energy developments and their cumulative impacts are one of the most important issues associated with the development of the Sunbelt's energy resources.

In addition to those areas likely to experience cumulative impacts, many areas may experience negative environmental consequences from the increased production of current resources. For example, oil and gas drilling activity has reached an unprecedented level in the major producing states of Region 6. In Oklahoma, approximately 300 communities depend on ground water to meet all of their water needs, and about 80 percent of the water used for irrigation comes from underground sources. Virtually all of the ground water supplies are located in the western half of the state, an area of increasingly heavy drilling activity. This increased drilling activity could lead to the contamination of water resources resulting from the inadequate disposal of drilling muds and brines.

Increased degradation of air quality and land use problems could result from the development of the Texas lignite belt. Even with the use of control technologies, the burning of coal can release substantial quantities of sulfur, nitrogen, and particulate matter. Between 1979 and 1988, Texas is scheduled to add 29 coal- and lignite-fired units that would burn 124 million tons of coal and lignite a year, in addition to the 47 million tons currently consumed by existing plants. Further, a number of synthetic fuel plants are planned for Texas. Current regulatory requirements could make it difficult to site the increasing number of coal fired power plants and synthetic fuel plants, and thus inhibit the development of these energy sources in Texas.

One of the major current and future environmental problems that is pervasive throughout the Sunbelt is the disposition of solid waste products from the various energy developments and facilities. This includes such things as spent nuclear fuel and low level radioactive wastes; scrubber sludge from coal-fired power plants; brine and drilling mud from oil, gas, and geothermal drilling; ash from coal synfuel plants; and spent shale from oil shale processing plants. For example, it has been estimated that:

- A well 8,500 to 11,500 feet deep requires 1,200 to 2,500 barrels of drilling mud;
- Over a 30 year period, a 50,000 bbl/d coal synfuels plant would produce enough ash to cover one square mile of land with waste piled 50 feet high;
- For a 50,000 bbl/d oil shale plant, there will be enough spent shale generated in one month to cover a square mile with 2 feet of wastes; and
- A typical nuclear plant (1,000 MW) produces about 30 tons of spent fuel per year. By the year 2000, demand for away-from-reactor storage capacity for spent fuel is projected to be over 16,000 metric tons.

The inadequate disposal of these and other solid waste products of energy developments could seriously impact surface and ground water supplies in many areas of the Sunbelt. This particularly could be a problem in those areas expected to experience multiple energy developments.

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CHAPTER 7

THE CHEMICAL INDUSTRY

HIGHLIGHTS

- Status and Trends

1. The chemical industry is the largest manufacturing industry in the Sunbelt. It is concentrated in Texas and Louisiana which house a very large proportion of the petrochemical industry; in Tennessee and Kentucky which provide a wide variety of chemicals; and in Florida which specializes in phosphate and other fertilizers. Most other Sunbelt states also show substantial growth in shipments of chemicals.

2. There is good evidence that the chemical industry will continue to grow in the Sunbelt for the foreseeable future, and thus will remain an important driving force for the economic development of the Sunbelt.

3. Most new refining capacity in the last ten years has been built in the Gulf area.

4. Virtually all new capacity in ethylene, propylene, and aromatics--the main feedstocks for petrochemical manufacture--has been sited in Texas and Louisiana, thus, ensuring that most plants for mainstream bulk chemicals will follow suit.

5. The growth of Sunbelt markets for consumer goods has attracted manufacturers of higher value added products such as soap and detergents, paints and varnishes, etc.

6. The growth in output will increase the volume of gaseous, liquid, and solid effluents. However, the implementation of environmental protection legislation passed in the 1970's and the technology developed by the industry to cope with these effluents will help to reduce the impacts which would have occurred in the absence of such legislation.

- Geographic Areas

  7. The Gulf Coast of Texas and Louisiana will be most affected by the growth of the chemical industry in the coming two decades. There will be some spreading of the industry along the Gulf Coast in Mississippi, Alabama, and Florida, and probably along the South Atlantic coast. Phosphate manufacture in Florida and the inland concentration of chemical plants in Tennessee and Kentucky are also areas where environmental issues are associated with chemical industry operations.

- Key Problems and Issues

  8. Environmental concerns as a result of the projected doubling of the capacity of the chemical industry in the next 20 to 30 years include the following:

     - Rapid urban development around the large concentrations of chemical plants along the Gulf Coast may lead to inadequate development of the necessary infrastructure in terms of housing, schools, roads, social services, etc.

     - Cumulative effects of gaseous and liquid effluents on air and fresh water quality in and around dense concentrations of chemical plants may increase public health risks.

     - Traffic congestion and hazards from toxic chemicals on roads and navigable rivers will be increased due to the increasing volume of chemical shipments.

     - With expanding production, there may be a shortage in hazardous waste management facilities and increased pollution from old, substandard facilities.

  9. Policy measures which may help to reduce the probability of the above adverse impacts occurring are:

     - The adoption of long-term planning procedures by local and state authorities in cooperation with the chemical industry to allow for a sustained growth of existing centers of chemical manufacturing.

     - Adoption of long term planning procedures by government authorities and industry for the identification and development of new sites for industrial growth along the Gulf and South Atlantic coasts.

- State and local policies to enhance the development of hazardous waste management industries, including effective regulation and monitoring of hazardous waste disposal sites.

- Cooperation among EPA, state and local authorities, and the industry in the implementation of the TSCA and RCRA.

- Federal government policies which encourage the industry to maintain its efforts in research, development, and innovation in the areas of environmental protection.

CHAPTER 7

THE CHEMICAL INDUSTRY

7.1 INTRODUCTION

The chemical industry is among the most important sectors of manufacturing in the industrially developed countries. Although it is expected that the high rates of growth experienced by the chemical industry in the European Economic Communities, the U.S., and Japan during the 1960's and 1970's (8-10 percent per year) will be reduced, the chemical industry will remain a growth industry for the foreseeable future with an annual growth rate of around 5 percent.

This confidence for the continuing growth of the chemical industry in the next 20 to 30 years springs from the fact that chemicals are essential for the basic needs of human societies: food production (fertilizers, insecticides, pesticides, food additives), clothing (synthetic fibers, dyestuffs), shelter (plastic materials), and health (pharmaceuticals). It is not, therefore, expected that market saturation will be attained for all those sectors in any country however high its per capita income. Other important considerations which lead to the same conclusion are that the industry produces both durable and nondurable goods and that the energy content of most chemical products, however large it is, is less than that of competing materials: cement, glass, aluminum, steel, etc.

For the specific case of the U.S. chemical industry the forecasts for its continuing growth are further supported by:

- The outstanding innovation record in terms of new products and new manufacturing processes;
- The availability of most raw materials, and particularly of natural gas, oil and coal; and
- The multinational character of many U.S. chemical firms which ensures market outlets worldwide.

A large segment of the chemical industry is situated in the South. It is the most important industry within the manufacturing sector in terms of employment, value added, and capital investment. All evidence in projections for the time horizon of this study, particularly those for capital investment, indicate that the chemical industry will expand in the future and will become one of the major driving forces for the economic development of the Sunbelt. This will be particularly the case in Texas, Louisiana, and possibly other states along the Gulf and South Atlantic coasts.

Important environmental considerations resulting from the expected growth of the chemical industry in the South may be related to:

- The fast growth of urban centers in Texas and Louisiana;
- The cumulative effects of pollutants in areas of dense concentrations of chemical plants;
- The need for safe disposal of hazardous wastes produced;
- The need for process water; and
- The transport of chemical products and waste.

7.2 CURRENT STATUS

The first generation of chemical manufacturing centers is in the coal mining areas along the banks of navigable rivers and lakes. The second generation centers are generally established in the proximity of large ports and oil refineries in deltas and estuaries of navigable rivers.

The chemical industry in the U.S. is concentrated in the following areas:

1. Around the Great Lakes and along the Ohio River in Illinois, Ohio, Michigan, and Indiana (Region 5).
2. In the Appalachian coal mining areas in Pennsylvania, Virginia, and West Virginia (Region 3), Tennessee and Kentucky (Region 4).
3. In New Jersey and New York (Region 2).
4. Along the Gulf Coast in Texas and Louisiana (Region 6).

Some other states, notably California and the Carolinas, have substantial chemical manufactures which are not, however, of the size and importance of the four mentioned above.

7.2.1 Geographical Distribution and Product Specialization in the Chemical Industry

Table 7-1 presents data on shipments and on capital investment from the 1977 Census of Manufactures for each state of federal regions 4 and 6 and for 11 other states outside our study area which have the largest chemical industries.

The following observations can be noted:

- Texas and Louisiana in the South and New Jersey in the North are the most important centers in terms of shipments.
- Texas with 2,361 million dollars and Louisiana with 1,613 million dollars are the most important centers in terms of capital investment.
- Considerable investments were made in New Jersey, Michigan, Ohio, Illinois, Pennsylvania, and New York.
- In terms of dollar value of shipments and investments, three and four Sunbelt states respectively are among the top ten.
- When shipments and capital investment in chemicals are expressed as percentages of those for the whole manufacturing sector, seven out of the ten top states in shipments, and eight out of the ten top states in investments are in the Sunbelt.

The Sunbelt states, with the exception of Texas, have smaller manufacturing sectors than most of the northern states of the sample. The fact that eight out of the thirteen Sunbelt states invested more than 19 percent of their total manufacturing investment in chemical plants emphasizes the economic importance of chemicals in the South.

Tables 7-2 and 7-3 present the geographic distribution of chemical manufactures in terms of seven groups of products: organic, inorganic, agricultural chemicals, plastics, drugs, soaps and detergents, and other chemicals.

The following observations can be made:

- Chemical manufactures in the South produce mainly bulk chemicals: organic, inorganic, and petrochemicals, plastics, and fertilizers;
- Chemical manufactures in the North, Northeast, and the West produce mainly consumer and high value-added

TABLE 7-1: SHIPMENTS AND CAPITAL INVESTMENT IN THE MANUFACTURING SECTOR AND IN CHEMICALS BY STATE
(in millions of dollars)

	Value of Shipments			Capital Investment		
	Total Manufacturing	Chemicals SIC 28	Percent[a]	Total Manufacturing	Chemicals SIC 28	Percent[a]
North Carolina	40,912 (10)	3,523	9	1,345	110	8
South Carolina	18,882	2,908	15 (6)	788	152	19 (9)
Tennessee	28,752	4,655 (9)	16 (5)	961	191	20 (7)
Kentucky	22,874	2,480	11 (9)	716	122	17
Georgia	32,856	2,387	7	1,143	223 (9)	20 (8)
Florida	20,980	2,646	13 (7)	737	142	19 (10)
Alabama	21,010	2,050	10 (10)	1,320	270 (6)	20 (6)
Mississippi	12,765	871	7	471	138	29 (5)
Texas	92,535 (5)	16,440 (1)	18 (4)	5,553 (1)	2,361 (1)	43 (3)
Arkansas	12,276	730	6	470	54	12
Oklahoma	12,563	383	3	497	76	15
New Mexico[b]						
Louisiana	29,500	8,109 (3)	28 (2)	2,167 (8)	1,613 (2)	74 (1)
California	120,896 (1)	6,183 (6)	5	3,385 (3)	237 (7)	7
Missouri	33,162	2,523	8	781	130	17
Ohio	95,234 (2)	6,758 (5)	7	2,790 (4)	232 (8)	8
Indiana	52,172 (8)	3,150	6	2,078 (9)	160	8
Pennsylvania	79,845 (7)	5,300 (8)	7	2,297 (7)	162	7
New Jersey	51,280 (9)	11,298 (2)	22 (3)	1,376 (10)	438 (3)	32 (4)
New York	86,216 (6)	5,357 (7)	6	2,530 (6)	300 (5)	12
Illinois	93,081 (4)	7,042 (4)	8	2,661 (5)	338 (4)	13
Michigan	93,757 (3)	3,761 (10)	4	3,740 (2)	---	--
Virginia	23,988	2,766	12 (8)	953	145	15
West Virginia	8,705	2,775	32 (1)	402	219 (10)	55 (2)

( ) = rating of states

Source: U.S., Dept. of Commerce, Bur. of Census, 1980-81.

[a] Chemicals as percent of total manufacturing.

[b] The New Mexico chemical industry is very small and the available figures are limited.

TABLE 7-2: VALUE OF SHIPMENTS BY STATE AND BY SECTOR OF THE CHEMICAL INDUSTRY
(in millions of dollars)

	Organics SIC 286	Plastics SIC 282	Inorganics SIC 281	Detergents and Soaps SIC 284	Drugs SIC 283	Other SIC 289	Agricultural SIC 287
North Carolina	298	1,609 (3)	130	211	607	146	-
South Carolina	300	1,755 (2)	-	-	-	-	-
Tennessee	751	1,496 (4)	1,600 (1)	153	216	197	197
Kentucky	666	858	497	-	-	-	74
Georgia	320	-	265	470	-	215	430 (6)
Florida	221	488	117	140	81	82	1,430 (1)
Alabama	597	-	342	106	-	-	321
Mississippi	46	207	-	-	-	-	307
Texas	10,167 (1)	2,707 (1)	1,124 (2)	362	153	661 (3)	810 (3)
Arkansas	193	-	-	-	-	23	156
Oklahoma	3	-	-	-	-	-	201
New Mexico	-	-	-	-	-	-	-
Louisiana	4,433 (2)	1,004 (6)	882 (4)	203	-	298	1,254 (2)
California	600	586	596	1,431 (4)	864 (5)	596 (5)	578 (4)
Missouri	317	-	-	621 (5)	455	288	406
Ohio	991 (4)	905	951 (3)	181	172	740 (2)	517 (5)
Indiana	154	323	213	478 (6)	1,373 (3)	119	383
Pennsylvania	850 (5)	589	812 (5)	344	1,880 (1)	330	154
New Jersey	2,727 (3)	950	637 (6)	2,465 (1)	-	641 (4)	163
New York	693	246	512	1,436 (3)	1,608 (2)	378	179
Illinois	728	749	438	1,922 (2)	984 (4)	995 (1)	310
Michigan	795 (6)	380	407	414	804 (6)	390 (6)	60
Virginia	-	1,476 (5)	214	-	348	144	106
West Virginia	1,788	705	172	-	-	78	-

SIC = Standard Industrial Classification

( ) = rating of states

Source: U.S., Dept. of Commerce, Bur. of Census, 1980-81.

TABLE 7-3: LEADING SECTORS OF THE CHEMICAL INDUSTRY BY STATE

	First	Second	Third
North Carolina	PLAST	DRUGS	ORGAN
South Carolina	PLAST	ORGAN	AGRIC
Tennessee	INORG	PLAST	ORGAN
Kentucky	PLAST	ORGAN	INORG
Georgia	DETER	AGRIC	ORGAN
Florida	AGRIC	PLAST	ORGAN
Alabama	ORGAN	INORG	AGRIC
Mississippi	AGRIC	PLAST	ORGAN
Texas	ORGAN	PLAST	INORG
Arkansas	ORGAN	AGRIC	--
Oklahoma	AGRIC	--	--
New Mexico	--	--	--
Louisiana	ORGAN	AGRIC	PLAST
California	DETER	DRUGS	ORGAN
Missouri	DETER	AGRIC	ORGAN
Ohio	DETER	ORGAN	INORG
Indiana	DRUGS	DETER	AGRIC
Pennsylvania	DRUGS	ORGAN	INORG
New Jersey	ORGAN	DETER	PLAST
New York	DRUGS	DETER	ORGAN
Illinois	DETER	OTHER	DRUGS
Michigan	DRUGS	ORGAN	INORG
Virginia	PLAST	DRUGS	INORG
West Virginia	ORGAN	PLAST	INORG

PLAST = plastics
INORG = inorganic chemicals
ORGAN = organic chemicals
AGRIC = agricultural chemicals
DRUGS = drugs
DETER = soap and detergents
OTHER = other chemicals

Source: U.S., Dept. of Commerce, Bur. of Census, 1980-81.

products: drugs, soap and detergents, perfumes, specialty chemicals, and plastics;

- Apart from Texas, Louisiana, and Tennessee the chemical industry of the other Sunbelt states consists of isolated manufactures: Florida produces phosphates and other fertilizers; Georgia, Mississippi, Alabama, Arkansas, and Oklahoma have rather small manufactures of agricultural chemicals and plastics; and
- Northern and northeastern states and California have more integrated chemical industries. Apart from their specialization in consumer and high value-added products, they also produce bulk chemicals but in smaller quantities.

The strength of the southern chemical industry derives from the existence of raw materials (oil, natural gas, coal, phosphates) and from the geographic advantages of the region (port facilities, navigable rivers, road and railway networks), rather than from the existence of local or regional markets, hence its specialization in bulk products. The relatively small manufactures (mainly plastics and agricultural chemicals) spread over most Sunbelt states cater to the local markets.

The opposite is true for most other states in our sample: the proximity of large urban centers and the dense population of these states is the reason for the strength of manufacturers of consumer products. Plastics products, soaps, and detergents have high transport costs and need to be manufactured as close to their market as possible. High value-added products such as drugs, perfumes, dyestuffs, and other specialty chemicals are products of intensive and highly specialized research and development (R&D). Their manufacturers tend to be near large university and research centers of excellence, which participate dirictly in corporate R&D or provide industry the environment and facilities conducive to innovation.

7.2.2 Employment and Income

Table 7-4 presents 1977 data on employment and income in manufacturing and in the chemical industry for the 24 states of our sample.

The following observations can be made:

- Despite the relatively small size of the manufacturing sector in the Sunbelt, four states are among the

TABLE 7-4: EMPLOYMENT AND INCOME BY STATE IN MANUFACTURING AND IN THE CHEMICAL INDUSTRY, 1977

	Employment Manufacturing	Employment Chemical	Pay Manufacturing	Pay Chemical	Chemical Employment	Chemical Payroll	Average Pay Manufacturing	Average Pay Chemical	Actual Pay Difference
	(in thousands of employees)		(in millions of dollars)		(percent)	(percent)	(in dollars per year)		
North Carolina	765 (9)	33 (9)	7,518 (10)	432	4 (3)	6 (7)	9,820	13,090	3,270
South Carolina	374	33 (10)	3,805	483	9 (4)	13 (4)	10,170	14,630	4,460
Tennessee	490	53 (4)	5,220	804 (4)	11 (3)	15 (2)	10,650	15,170	4,520
Kentucky	277	16	3,452	245	6 (6)	7 (6)	12,460	15,600	3,140
Georgia	484	15	5,124	200	3	4	10,580	13,260	2,640
Florida	358	21	4,133	303	6 (6)	7 (6)	11,540	14,420	2,880
Alabama	341	13	3,773	202	4	5	11,060	15,530	4,470
Mississippi	219	6.6	2,061	83	3	4	9,410	12,570	3,160
Texas	890 (7)	70 (2)	11,700 (7)	1,228 (2)	8 (5)	10 (5)	13,140	17,540	4,400
Arkansas	197	6	1,932	95	3	5	9,800	15,830	6,030
Oklahoma	168	2	2,100	27	1	1	12,500	13,500	1,000
New Mexico	29	0.8	297	12	2	4	10,240	15,000	4,760
Louisiana	194	31 (11)	2,674	593 (9)	16 (1)	22 (1)	13,780	19,130	5,350

(continued)

TABLE 7-4: (continued)

	Employment Manufacturing	Employment Chemical	Pay Manufacturing	Pay Chemical	Chemical Employment	Chemical Payroll	Average Pay Manufacturing	Average Pay Chemical	Actual Pay Difference
	(In thousands of employees)		(In millions of dollars)		(percent)	(percent)	(In dollars per year)		
California	1,751 (1)	53 (4)	24,671 (1)	781 (5)	3	3	14,090	14,730	640
Missouri	433	24	5,709	326	6	6	13,200	13,600	400
Ohio	1,331 (3)	45 (6)	20,356 (3)	712 (7)	3	4	15,290	15,820	530
Indiana	706 (10)	25	10,439 (9)	455	4	4	14,780	18,200	3,420
Pennsylvania	1,329 (4)	44 (7)	18,042 (6)	692 (8)	3	4	13,570	15,720	2,150
New Jersey	778 (8)	96 (1)	10,924 (8)	1,587 (1)	12 (2)	15 (3)	14,040	16,530	2,490
New York	1,510 (2)	52 (5)	20,876 (2)	759 (6)	3	4	13,820	14,590	770
Illinois	1,286 (5)	55 (3)	18,740 (5)	829 (3)	4 (8)	4	14,570	15,070	500
Michigan	1,116 (6)	34 (8)	20,054 (4)	575 (10)	3	3	17,960	16,910	-1,050
Virginia	395	33	4,442	510	8	11	11,240	15,400	4,160
West Virginia	117	19	1,620	327	16	20	13,840	17,200	3,360

( ) = rating of states

Source: U.S., Dept. of Commerce, Bur. of Census, 1980-81.

top ten in terms of employment in the chemical industry;

- When employment and total payroll in the chemical industry are expressed as percentages of the total in manufacturing, eight and seven Sunbelt states respectively are among the top ten; and

- The average pay in manufacturing is considerably lower in the South than in the North. But this difference is very much reduced when the comparison is limited to employees in the chemical industry.

These observations underline the importance of the chemical industry as a driving force, not only in manufacturing but also in the economic development of the Sunbelt. The considerable difference in pay between manufacturing as a whole and the chemical industry puts pressure on local and state authorities to provide incentives in terms of taxation and industrial zoning for the chemical industry to invest within their borders.

The generally lower wages paid in the South have acted as a further incentive for the industry to move there because of the resulting lower cost in services, transport, and unskilled labor. Thus, it appears that the chemical industry was and will be a major driving force in the industrial and economic development of the Sunbelt.

7.2.3 Recent Trends

Table 7-5 presents Census of Manufactures data on recent employment and value-added trends (1972-1977) in the manufacturing sector and in the chemical industry for the states of the sample.

The following observations can be noted:

- Manufacturing employment increases in the South range from 3 percent for North Carolina to 21 percent for Texas, the average for Regions 4 and 6 being 9 percent;

- Manufacturing employment increased in California by 13 percent, while in the North and Northeast it ranged from a decline of 10 percent for New York to a growth of 7 percent for New Jersey. The average for the nine states of the North and Northeast showed no change;

- Employment in the chemical industry over the five year period increased in the Sunbelt states by an

TABLE 7-5: GROWTH OF MANUFACTURING AND THE CHEMICAL INDUSTRY, 1972-1977

	Percentage Increase In Employment		Percentage Increase In Value-Added	
	Manufacturing Employment	Chemical Industry	Total Manufacturing	Chemical Industry
North Carolina	3	2	66	86
South Carolina	8	20	65	78
Tennessee	5	5	65	63
Kentucky	7	21	68	107
Georgia	4	10	70	121
Florida	4	13	60	71
Alabama	6	26	66	103
Mississippi	9	24	99	89
Texas	21	24	116	122
Arkansas	9	40	74	159
Oklahoma	18	105	NA	NA
New Mexico	NA	NA	NA	NA
Louisiana	9	27	122	158
Study Area Average	9	26	80	105
California	13	17	76	62
Missouri	0	3	61	74
Ohio	-1	-5	58	62
Indiana	0	2	61	49
Pennsylvania	-6	-8	53	55
New Jersey	7	-2	39	54
New York	-10	-3	46	56
Illinois	-2	5	56	67
Michigan	4	0	61	55
Virginia	5	0	76	74
West Virginia	3	-10	47	39
North and Northeast Average	0	-3	56	57

NA = Not Available

Source: U.S., Dept. of Commerce, Bur. of Census, 1980-81.

average of 26 percent and in California by 17 percent. In the North and Northeast there was an overall decline in employment; West Virginia experienced the largest decline (10 percent) and Michigan experienced no change. Exceptions were Illinois (+5 percent) and Indiana (+2 percent);

- Value-added for manufacturing showed an average increase of 80 percent for the Sunbelt states, 76 percent for California, and 56 percent for the North and Northeastern states of the sample; and

- Value-added for the chemical industry increased by 105 percent in the South, 62 percent in California, and 57 percent in the North and Northeast.

The above observations show further evidence of the expansion of the manufacturing sector in the South. The chemical industry underwent even greater expansion both in terms of employment and value-added. Figures on employment and on valued-added should be interpreted as mutually dependent because of the relationships among types of products, manufacturing processes, and market outlets. For example, in Georgia, a small increase in employment raised the value-added by 121 percent. This is because of the establishment of soap and detergent manufactures whose products have a high value-added.

The average values of growth experienced in the period 1972 to 1977 produce an indication of the trends that may be expected for the early part, at least, of the time horizon of this study.

7.2.4 Oil Refining Industry

The oil refining and chemical industries have close institutional and geographic relationships. Most major oil refining firms became important chemical manufacturers (e.g., Exxon and Standard Oil of Ohio [Sohio]) or have merged with chemical firms (DuPont-Tenneco). On the other hand--and of more importance to this study--chemical manufacturing plants are built near oil refineries which provide the feedstocks and their by-products as well as the cost advantages of transporting intermediate and end products rather than raw materials.

Table 7-6 shows this relationship in a clearer way. The data are again from the 1977 Census of Manufactures. States with large oil and gas production and refining industries are those with large chemical industries as well (Table 7-1). Texas, Louisiana, California, Illinois, Pennsylvania, Ohio, and Indiana have, or have had, important oil and gas resources. Exceptions are New Jersey, which has a large oil refining and chemical industry based on imported oil, and Oklahoma, which is a major oil

TABLE 7-6: OIL AND GAS AND OIL REFINING INDUSTRIES (SIC 29 AND SIC 2911) (in millions of dollars)[a]

	Oil and Gas Industry					Oil Refining Industry				
	1977 Materials	1977 Shipments	1977 Value-Added	1972 Value-Added	1977 Capital Investment	1977 Materials	1977 Shipments	1977 Value-Added	1972 Value-Added	1977 Capital Investment
North Carolina	70	85	15	13	1					
Tennessee	270	371	104	18	3					
Georgia	178	228	52	43						
Florida	77	105	29	26	3					
Alabama	473	556	89	-	-	395	436	46	13	
Texas	23,958 (1)	29,702	4,277	1,338	1,171	23,712 (1)	27,734	4,155	1,274	1,155
Arkansas	370	436	77	35	8					
Oklahoma	7,940 (4)	3,350	438	104	90	2,840 (7)	3,218	406		88
Louisiana	9,345 (3)	11,134	1,844	442	136	9,140 (3)	10,813	1,718	408	131
California	9,981 (2)	12,460	2,540	725	153	9,610 (2)	11,871	2,315	615	131
Missouri	524	684	161	--	13	--	--	--	--	--
Ohio	3,333 (8)	3,953	645	311	48	221	427	206	113	18
Indiana	2,450 (9)	2,727	324	219	97	2,361 (8)	2,595	279	184	94
Pennsylvania	4,546 (6)	5,553	1,064	350	87	4,279 (5)	5,161	939	263	77
New Jersey	3,930 (7)	4,126	210		63	3,693 (6)	3,782	101	--	52
New York	630	756	178		18					
Illinois	6,008 (5)	7,463	1,466	410	71	5,596 (4)	6,834	1,248	27	62
Michigan	894	1,080	185	168		781	903	131	--	--
West Virginia	219	251	35	26	14	--	--	--	--	--

Source: U.S., Dept. of Commerce, Bur. of Census, 1980-81.

[a] No figures for South Carolina, Kentucky, Mississippi, Virginia, and New Mexico.

and gas producing state but exports most of its product via pipelines to major population centers. The discrepancies between these two states underline the importance of having a coastline or navigable rivers for transport, process water, and effluent disposal.

The data on investment in the period 1972 to 1977 are consistent with large expansions of refining capacity in Texas, Louisiana, and California, controlled growth in Pennsylvania and Indiana, and modest growth for the other states of the sample, including New Jersey. These trends will affect, in a parallel way, future developments of the chemical, and particularly the petrochemical, industry.

7.2.5 Federal Environmental Protection Legislation Affecting the Chemical Industry

Federal environmental legislation dealing with toxic substances which affect the chemical industry can be divided into two groups (Table 7-7): the first six statutes which were passed prior to or during 1974 and to which the industry has adapted to a considerable extent; and two more recent acts passed in 1976--the Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act (TOSCA)--which have only been partially implemented to this date.

Although the legislation in the first group was not directed specifically at the chemical industry, industry activities were greatly affected. For example, in 1975, 11 percent of total capital investment in the chemical industry (684 million dollars) was spent for pollution control. The peak was reached in 1976 with 13 percent (765 million dollars) ("Facts and Figures," 1980). From then on capital investment for pollution control remained at a moderate level, about 5 percent of total capital investment.

Table 7-8 shows the relative decline of pollution control investment by the chemical industry in the years 1978 to 1980, a decline which some other industries, notably iron and steel, petroleum, nonferrous metals, paper, etc., did not experience ("Facts and Figures," 1980). It is also interesting to note in Table 7-8 that the major thrust of pollution control investment was in air and water, the most stringently regulated areas, with much less in solid waste management. Furthermore, R&D effort devoted entirely to coping with environmental legislation does not exceed 13.5 percent of total R&D effort according to a number of R&D managers who were interviewed by a University of New Orleans team (Iverstine, Kinard, and Slaughter, 1978).

Serious human health effects due to benzene were noted before 1959 when 140 fatal cases of poisoning were studied (Elkins, 1959, p. 103). Vigliani and Saita (1964) listed 26 deaths from

TABLE 7-7: FEDERAL LAWS DEALING WITH TOXIC SUBSTANCES

Statute	Sources Covered
Clean Air Act (1970)[a]	Hazardous air pollutants
Federal Water Pollution Control Act (1972)[a]	Toxic water pollutants
Safe Drinking Water Act (1974)	Drinking water contaminants
Federal Insecticide, Fungicide, and Rodenticide Act (1972, 1975)	Control of pesticides
Act of July 22, 1954 (§346(a) of the Federal Food, Drug, and Cosmetic Act)	Tolerances for pesticides in human and animal feeds
Marine Protection, Research and Sanctuaries Act (1972)	Ocean dumping of chemicals
Resource Conservation and Recovery Act (1976)	Hazardous waste management
Toxic Substances Control Act (1976)	Premanufacture evaluation of all new chemicals (other than food, food additives, drugs, pesticides, alcohol, tobacco); allows EPA to regulate existing chemical hazards not sufficiently controlled under other laws

Source: Temple, 1979, p.15.

[a] Substantial amendments were passed in 1977.

TABLE 7-8: INDUSTRY CAPITAL SPENDING FOR POLLUTION CONTROL PROJECTS (million of dollars)

Industry	1978						1979						1980					
	Total Capital Invest-ment	Pollu-tion Con-trol	%	Air	Water	Solid Waste	Total Capital Invest-ment	Pollu-tion Con-trol	%	Air	Water	Solid Waste	Total Capital Invest-ment	Pollu-tion Con-trol	%	Air	Water	Solid Waste
Chemicals	7,100	565	8	236	286	42	8,560	440	5	203	184	53	9,280	476	5	218	205	53
Food and Beverage	4,870	172	4	175	175	22	5,060	148	3	61	84	13	5,280	150	3	51	83	16
Iron and Steel	2,460	441	18	290	140	10	2,970	510	17	351	154	5	3,530	638	18	435	97	6
Nonferrous Metals	2,450	247	10	189	53	5	2,610	213	8	142	58	13	3,120	286	9	187	76	23
Paper	3,460	239	7	105	103	31	4,880	297	6	133	124	40	6,010	300	5	135	125	40
Petroleum	15,500	1,294	8	611	586	98	6,620	1,386	8	708	530	147	19,340	1,536	8	844	565	127
All Manu-facturing	67,620	3,951	6	1,992	1,652	306	8,920	3,976	5	2,103	1,493	381	90,200	4,540	5	2,515	1,642	383

Source: Data compiled from U.S. Department of Commerce, as cited in "Facts and Figures" 1980.

chronic benzene poisoning in two provinces in Italy between 1960 and 1963. Eleven of these were diagnosed as leukemia. Despite the early reports ascribing low toxicity to vinyl chloride, injury during production of polyvinyl chloride (PVC) resins was reported as early as 1949. A report by Viola et al. (1971), is the earliest publication in which carcinogenic activity has been ascribed to vinyl chloride in man or animals. Evidence has also shown that very little is known about how and to what extent chemical substances may affect human health (U.S., CEQ, 1977 and 1980). Increasing concern about the potential health hazards of chemical substances led Congress in 1976 to pass the second group of statutes, namely the RCRA and the TOSCA, which are directed mainly towards the chemical industry.

The U.S. chemical industry is conscious of the image it projects to the public and its effect on public opinion in its effort to reduce air and water pollution and to protect worker safety and health (Holmer, 1980). Table 7-9 presents the results of a public opinion survey carried out by a consulting firm for industries perceived as having done a poor job of complying with environmental protection laws and guidelines. The Chemical Manufacturers' Association has recently increased its cooperation with EPA in dealing with risks from the transport of chemicals and for managing specific hazardous waste disposal sites. The Chemical Industry Institute of Toxicology, formed in 1974, is funded by 34 firms and carries out research to determine the possible health effects of major commodity chemicals and to develop improved test methods to evaluate health hazards. The American Industrial Health Council--a non-profit organization financed by the chemical industry--is working with government agencies to develop new standards for employee health in the industry.

7.3 FUTURE DEVELOPMENT AND ENVIRONMENTAL ISSUES

7.3.1 Expansion of the Chemical Industry in the South

The information in the previous section suggests that the chemical industry will continue to expand in the South during the coming 20 to 30 years. This expansion will be an important driving force for the economic development of the southern states, particularly those along the Gulf and South Atlantic coasts. The following factors are among those which will combine to bring about this development:

1. The chemical industry will grow worldwide. Forecasts are that its output will double by the end of this century--on the basis of the versatility of its products and their use in both consumer and capital goods. The U.S. chemical industry, the largest in

TABLE 7-9: INDUSTRIES SEEN AS HAVING DONE A "POOR JOB" OF COMPLYING WITH [ENVIRONMENTAL] LAWS AND GUIDELINES

Industry	Poor Job on Air Pollution	Poor Job on Water Pollution	Poor Job on Health and Safety
Chemicals	56%	51%	36%
Oil	34%	39%	20%
Steel	30%	27%	22%
Electricity Utilities	15%	15%	10%
Mining	--	--	37%
Forest Products	17%	18%	5%

Source: Holmer, 1980 (Survey carried out by Yankelovich, Skelly, and White, Inc.).

the world, will share in that growth (see Figure 7-1);

2. The South offers important geographical advantages in terms of proximity to foreign markets (South America, Africa, and Western Europe); proximity to feedstocks (gas and oil in Texas, Oklahoma, Louisiana, Mexico, and Venezuela; and coal in Texas, Kentucky, and Tennessee); and good transport networks (ports in the Gulf and the Atlantic Coast and navigable rivers to the interior);

3. Large investments in chemical plants have been made in the last 40 years. The Gulf Coast of Eastern Texas and Louisiana has the largest concentration of chemical plants in the U.S.[1] Some decrease in activities will occur in Kentucky and Tennessee but this will be more than balanced by investments in the Carolinas;

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[1] Nearly all expansion in ethylene, propylene, butadiene, and aromatics capacity in the last 10 years was in Texas and Louisiana (Wett, 1981).

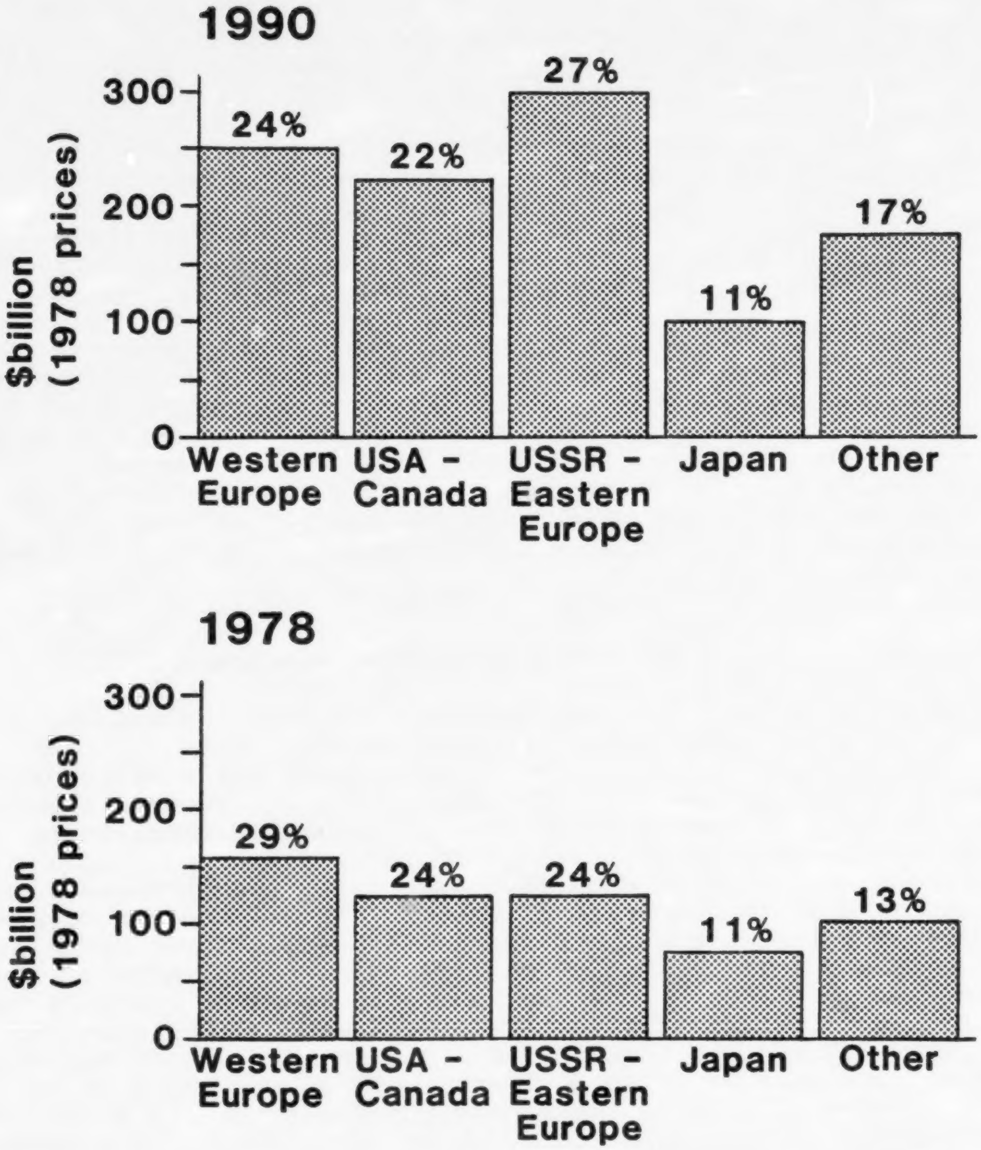

Figure 7-1: World Chemical Production[a]

Source: Telfer, 1980, p. 29.

[a] Actual figures for 1978, estimated figure for 1990. Average growth rates (percent per year) are: World 5.7, Western Europe 4.0, North American 5.0, Eastern Europe and USSR 7.0, Japan 5.5, Others 8.0.

4. The trend of internal migration of population to the South and the growth of its urban centers will call for the establishment there of manufactures of chemical consumer products such as detergents, soaps, paints, varnishes, and solvents; and

5. State and local authorities will provide incentives for the chemical industry to expand in their areas because of the employment opportunities it creates, the relatively higher wages it pays, the establishment of secondary industries, the growth of the local service sector, and the expansion of the tax base.

The Bureau of Economic Analysis (BEA) of the Department of Commerce forecasts considerable growth in the chemical industry for most southern states. Their projections are presented in Table 7-10 and cover the period 1978 to 2010. Given the very long time horizon, the details of the figures presented in the table, which were calculated by the extrapolation and moderation of current trends, may be challenged, but the general trend of growth seems to be plausible (see chapters 3 and 4) for reasons given above.

7.3.2 Concentrated Urban and Industrial Development

Recent investments in the chemical and refining industries in the West, North, and Northeast indicate that there will not be a rush of chemical manufacturers to the South, but an accelerating trend of building new capacity there. The BEA forecasts more than 200 percent growth of chemicals in most southern states. Given the current concentrations in Texas and Louisiana, a further doubling of plant capacity there will have different consequences than the doubling of capacity in Oklahoma or Mississippi. All indications so far point to the Gulf and South Atlantic coasts for accommodating most of the expected growth. Doubling employment in the chemical industry means an extra 70,000 employees in Texas, 50,000 in Tennessee, and 30,000 each for Louisiana, North Carolina, and South Carolina. These employees and workers will be urban dwellers; most of them will probably move from outside these areas, bringing their families, thereby raising the local population by about three times their numbers. Local authorities will have the responsibility for providing the necessary infrastructure in terms of housing, schools, roads, social services, etc. Unless this is done in time, increasing chemical manufacturing capacity may lead to increased environmental concerns resulting from both industrial and urban development.

TABLE 7-10: REPORTED AND PROJECTED INDUSTRY EARNINGS[a] FOR CHEMICALS AND ALLIED PRODUCTS (SIC 28) (in millions of 1972 dollars)[b]

	1978	1985	1990	2000	2010	% Change 1978-2010
Alabama	192.4	266.0	329.0	464.6	629.7	227.3
Arkansas	91.5	137.6	176.2	263.6	370.2	304.6
Florida	300.8	395.9	473.8	626.1	812.0	169.9
Georgia	181.2	258.4	325.7	474.5	655.8	261.9
Kentucky	215.7	280.0	328.2	399.4	486.9	125.7
Louisiana	510.8	846.1	1,167.3	1,895.9	2,790.7	446.3
Mississippi	74.6	115.8	153.1	240.6	347.6	366.0
New Mexico	6.0	7.6	9.0	11.9	15.5	158.3
North Carolina	410.8	623.5	799.5	1,172.1	1,614.4	293.0
Oklahoma	39.4	60.8	81.6	127.7	184.1	367.3
South Carolina	386.6	532.2	656.2	919.1	1,239.0	220.5
Tennessee	747.1	981.1	1,164.2	1,519.1	1,953.0	161.4
Texas	1,210.9	1,809.7	2,357.5	3,460.0	4,803.3	296.7
Region 4	2,509.2	3,452.9	4,229.7	5,815.5	7,738.4	208.4
Region 6	1,858.6	2,861.8	3,791.6	5,759.1	8,163.8	339.2
Region 5[c]	3,097.9	4,064.4	4,848.9	6,405.9	8,307.3	168.2
Region 2[c]	2,863.9	3,650.0	4,284.5	5,513.9	7,033.8	145.6
Region 3[c]	2,302.8	2,894.7	3,339.2	4,157.8	5,175.9	124.8

Source: U.S., Dept. of Commerce, BEA, 1980.

[a] Labor and proprietor's income (see Chapter 4 for further explanation).

[b] Regions 2, 3, and 5 were selected for comparison because their projected income from SIC 28 was higher than that of any of the other regions.

[c] Region 5 includes the states of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin; Region 2 New York and New Jersey; and Region 3 Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia.

7.3.3 Water Use

Figure 7-2 presents projections from the Second National Water Assessment (U.S., Water Resources Council, 1978, pt. 3, p. 45) for fresh water withdrawal and consumption by the chemical industry to the year 2000. The four areas in Figure 7-2 include the major riverine chemical manufacturing regions. Except for the Texas Gulf region, fresh water withdrawals are expected to drop considerably. These reductions will result from recycling process water in manufacturing plants--a trend accelerated by the enforcement of the Clean Water Act (CWA) and, in the Texas Gulf and Lower Mississippi region, by the large scale use of saline and brackish water. In spite of the projected reduction in withdrawals, consumption of fresh water is projected to increase, not only because of the expected growth of the chemical industry, but also because complying with the CWA encourages increased consumption through the use of evaporative holding ponds. For example, fresh water consumption by the chemical industry in the Texas region is projected to increase by about 400 percent (see Chapter 13). A basic assumption for these projections is that the major goals of the CWA will continue to be enforced (see Chapter 14). The increased pressures on limited water resources may be one of the reasons for consideration of creating new manufacturing sites for the chemical industry.

7.3.4 Siting of Chemical Plants

The southern coastal manufacturing sites will maintain their attractiveness for the industry in the foreseeable future. This will be particularly true for the Texas-Louisiana Gulf Coast sites which--apart from the benefits of large ports, navigable rivers and refineries--will have feedstocks available from nearby oil and natural gas wells. The projections for oil and gas prices and their decontrol will encourage increased exploration and production from new and existing wells, and from increased secondary and tertiary recovery. Imports of gas and oil from Mexico will also become an important source for feedstocks.

Siting of chemical plants in new coal mining areas (e.g., Wyoming and Montana in the U.S. and Alberta in Canada) if and when the production of synfuel acquires momentum, will probably not occur before the year 2000 because (a) there are considerable opportunities for energy conservation, as shown by the chemical industry's record so far in reducing energy use per pound of product by 18 percent between 1972 and 1978, and its target towards an overall 30 percent improvement by 1985; and (b) most petrochemical processes were developed in a period of declining oil prices so that energy conservation was not a prime developmental concern, thus allowing for improvement in fuel and feedstock efficiency and for the design of new technologies which require less energy (U.K., Dept. of Energy, 1975). If

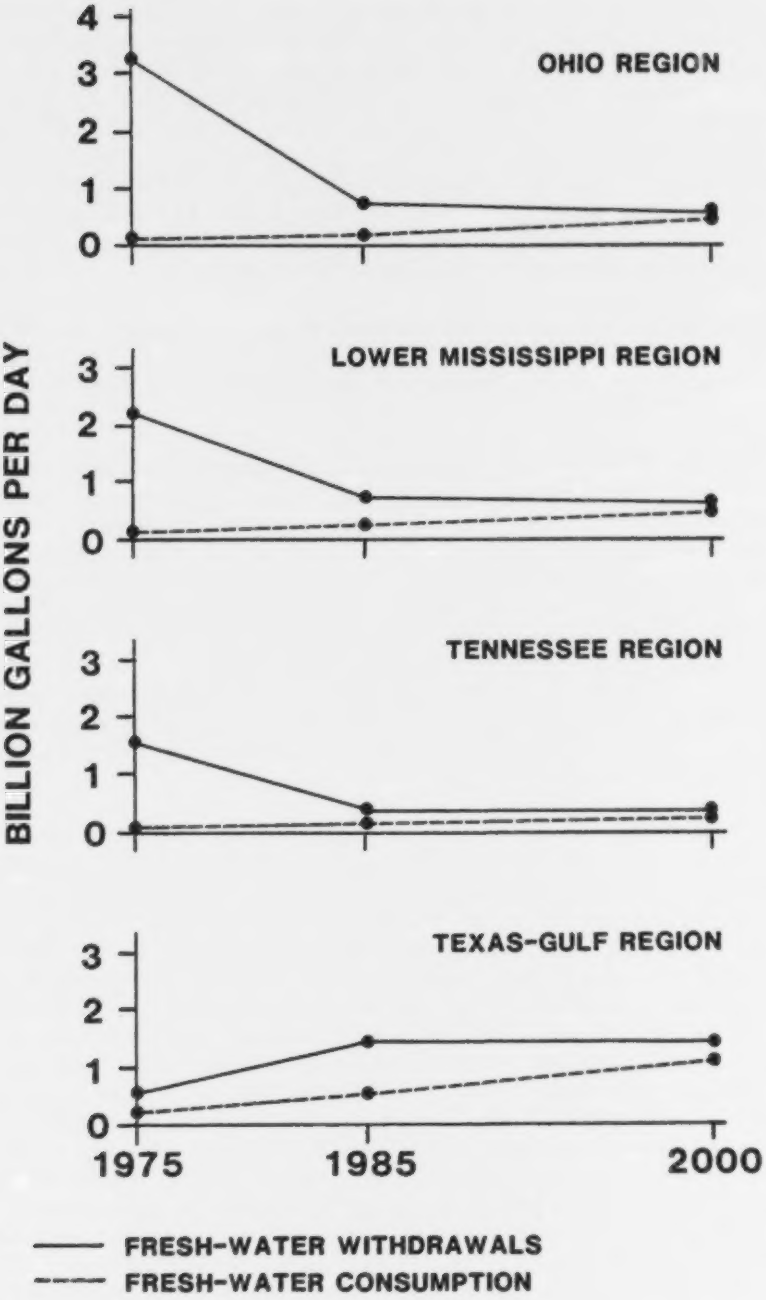

Figure 7-2: Water Use by the Chemical Industry

Source: U.S., Water Resources Council, 1978, Pt. III, p. 47.

commercially competitive feedstocks are produced elsewhere, it may prove less costly for the industry--given its heavy capital investment in existing sites and their advantage with respect to established product transport--to channel those feedstocks by pipeline to existing sites rather than relocate. The real problem with chemicals from coal in this century--aside from economics--is the lead time for installation of large scale commercial coal conversion processes. No commercial size reactors have operated in the U.S., no firm environmental impact information is available to pin down pollution problems.

The expansion of petrochemical manufacturing in Mexico enhances the importance of the U.S. Gulf Coast chemical manufactures because they have competitive transport costs to Latin America.

Apart from the above technical/commercial advantages, an important factor for the expansion of existing sites rather than the establishment of new ones is the encouragement of developers by local and state authorities in terms of financial and tax incentives and zoning regulations. Local and state authorities enjoy the considerable economic benefits in terms of jobs, higher than average paychecks, secondary industry, expansion of services, housing, and growth of the tax base. Lastly, expansion will face less local resistance than siting in new areas since people living in unindustrialized areas object much more strongly to incoming industry than do people living in the vicinity of already industrialized zones.

Given the size of the projected growth of the chemical industry and its inelasticity in siting, a major environmental concern for Regions 4 and 6 will be the cumulative effects of gaseous, liquid, and solid effluents on air and fresh water quality in and around dense concentrations of chemical plants, on neighboring estuaries and coastlines, and on the health of people living in adjacent areas. Evidence of such environmental degradation can be found in Baton Rouge and Lake Charles, Louisiana; Beaumont, Port Arthur, and Galveston, Texas; and Memphis, Tennessee. For example, the manufacture of the whole range of petrochemicals in Baton Rouge, Louisiana, which include proven or suspected carcinogens like benzene, acrylonitrile, ethylene oxide, vinyl chloride, and carbon black, is suspected of being associated with the increased incidence of some types of cancer in the area, although it is difficult to prove direct cause and effect linkages (Levin et al, 1974; Jellinek, 1978; U.S., EPA, ORD, 1980). Given the projected concentrated growth of the industry, stricter regulations for the discharge of pollutants in gaseous, liquid, and solid effluents, increased monitoring, and systematic evaluation of the carrying capacities of air and river and coastal waters may be required.

While economic factors may favor expanding existing sites, it may, however, prove impossible to accommodate the expected growth of the industry by expansion because of physical, technical, social, and environmental constraints. In this case it is possible that the geographic advantages of regions 4 and 6 and the policies of state authorities to create employment opportunities will lead to the establishment of new chemical (and petrochemical) manufacturing centers. The coast of North Carolina, South Carolina, and Georgia, if provided with deepwater port facilities, may offer some attractive locations, particularly should extensive LNG (liquefied natural gas) imports from Algeria and Middle Eastern countries develop. The Gulf Coast of Alabama, Mississippi, and Florida may also provide similar sites.

These possible developments suggest that EPA, state and local authorities, coastal zone management commissions, and industry should cooperate to identify new sites along the coasts, and to evaluate the industrial capacity that can be accommodated. It is known from the experience in siting major energy facilities in the U.S. and western Europe that long term planning and selection of sites helps to reduce public opposition, leads to the choice of the most suitable sites, and reduces adverse impacts by identifying them in advance (OECD, Environment Directorate, 1979).

7.3.5 Management of Hazardous Chemical Waste (also see Chapter 15)

The chemical industry has been generating large volumes of waste since the industrial revolution, the huge deposits of calcium sulfide from alkali manufacture being one of the trademarks of that period. More recently, the huge expansion and character of the industry's output (e.g., pesticides) has led to the production of waste materials which are highly toxic and which must be safely disposed of to avoid health hazards. The physical state, volume, nature, and toxicity of waste generated by the chemical industry varies greatly and includes very large volumes of solid inert materials like calcium phosphate or calcium carbonate, large volumes of liquid by-products of petrochemical manufacture, small amounts of known carcinogens such as polychlorinated biphenyls, and small amounts of trace metals like mercury and cadmium. The large size of the chemical industry in the Sunbelt results in the production of most kinds of hazardous waste and the projected growth of the industry in the time horizon of this study indicates that the problems associated with the safe disposal of that waste may become more complicated.

Data on hazardous waste generation by the chemical industry are presented in Chapter 15 (tables 15-2 and 15-3). One estimate is for 6 million metric tons per year in Region 4, and 3 million metric tons for Region 6. The other estimate is for 15 million metric tons for Region 4, and 9 million metric tons for Region 6. Despite the wide discrepancies between the two estimates, both agree that the chemical industry is responsible for the bulk of the hazardous waste in regions 4 and 6. The waste in Region 4 is mainly inorganic because of the predominance of inorganic chemicals and fertilizer manufactures and is disposed of mostly in landfills. The waste in Region 6 is mainly organic because of the petrochemical industry and is disposed of in ponds, injected into deep wells or incinerated. It is estimated that regions 4 and 6 have, for the time being, excess waste disposal capacity, but it is expected--particularly for Region 4--that this will not be the case in the future because of the expansion of the industry and the enforcement of the RCRA which will inevitably preclude the use of some current sites.

The passage of RCRA and TOSCA has accelerated the establishment and growth of the hazardous waste disposal industry. This is a welcome development because:

- It will lead to safer methods for waste disposal;
- It will facilitate the task and decrease the number of regulatory and enforcement authorities by better identifying regulated agents; and
- It will facilitate the safe disposal of waste generated by small producers.

Large companies, wherever the volume of waste generated allows for the payback of investment in waste treatment plants, will go ahead with on-site treatment. High temperature incineration on the open seas on specially built ships will increase. Both the cost of shipping waste and technological advances will help to reduce the ratio of waste to product. And in the next 20 to 30 years the ratio of waste to product will decrease in the chemical industry due to new methods for treatment and to the legislation in force. Our knowledge of relations between chemical structure and the incidence of illness will increase so that controls on the production, use, and disposal of chemicals will be founded on a more solid basis and will become more selective than is possible today. We may, therefore, expect that by the end of the century fewer toxic waste disposal sites will be needed and that they will belong mostly to a well defined waste disposal industry which will be monitored by local, state, and federal agencies. The latter may also own and manage such sites in the same way they do today with water treatment and sewage plants.

For these developments to occur, government and industry need to address these questions without delay. Enforcement of RCRA and TOSCA provides the opportunity for cooperation among EPA, state and local authorities, and industry to develop networks of hazardous chemical waste facilities which will ensure the protection of the environment and the growth of the industry.

7.3.6 Transport of Hazardous Chemicals

Most chemicals, and in particular petrochemicals, are not sold directly to consumers, but to other manufacturing industries for further transformation (see Table 7-11). Transport of these products is a major activity involving pipelines, barges, ships, tankers, railways, and trucks. The extremely toxic character of some high value-added, less bulky products (insecticides, pesticides/fungicides) and the explosive character of some gases (acetylene, hydrogen, oxygen, ethylene oxide) increase the hazards involved. The probability for accidents is multiplied by the density of chemical plants in a few geographical areas.

Sea and barge transport will become particularly important in the next 20 to 30 years ("Storage," 1974). Both methods are less expensive and less hazardous than road or rail transport, and the geographical development of the chemical industry in the South favors them. Congestion may be expected to occur in the existing harbors and navigable rivers. Government agencies and industry will have the task of ensuring that these routes have the capacity to accommodate the growth expected while maintaining safety precautions to prevent accidents and chemical spills.

7.3.7 Research and Innovation

There are some reports that R&D activities have been affected in the past, and will be affected even more in the future, by the implementation of environmental legislation. Some indications were interpreted as evidence that industry was diverting R&D funds away from the development of new products and processes to the development of production processes to suit environmental legislation (Iverstine, Kinard, and Slaughter, 1978; Chilton and Hawley, 1980; U.S., EPA, ORD, 1980). However, the indications of this trend are not convincing so far. The chemical industry in all Organization for Economic Cooperation and Development (OECD) countries has been reducing investment in R&D since the oil price crisis in 1973. A trend towards incremental, and away from radical, innovation was established since the late 1960's. The oil price crisis, by introducing more uncertainty for the future, helped to enforce that trend. It was only a coincidence that the Clean Air Act and the CWA were introduced in that period of time and that some R&D funds were used to develop processes to enable the industry to comply with the new legislation. The recent increases in R&D budgets in OECD countries, which are to be found in most sectors of industry and not only in chemicals,

TABLE 7-11: FEEDSTOCK, PETROCHEMICALS, AND INDUSTRIES DEPENDENT ON PETROCHEMICALS

Feedstocks[a] (raw materials)	Petrochemical Materials[a]			Industry Users[a]	Consumer Demands[a]
	"Primary" or "Basic" Petrochemicals	"Intermediate" Petrochemicals	Petrochemcials "Products"		
Natural Gas		Ethylene Glycol	Plastics	Coatings	Paints
Methane	Methanol	Ethylene Dichloride		Construction	Plywood
		Vinyl Acetate		Electrical	Wire coating
Natural Gas Liquids	Unsaturates	Vinyl Chloride		Housewares	Seat covers
Ethane	Ethylene	Acrylonitrile		Packaging	Containers
Propane	Propylene			Transportation	Engineering material
Butane	Butylene				
LPG	Acetylene				
Pentanes			Synthetic fibers	Apparel	Clothing
Natural Gasoline				Textiles	Rugs
				Home furnishings	Upholstery fabric
				Tires	Tire cord
Petroleum Liquids	Aromatics		Solvents	Dry cleaning	Cleaning fluids
LPG	Benzene	Ethylbenzene			
Naphtha	Toluene	Styrene Monomer		Cosmetics, drugs	Personal care items
Reformate	P-Xylene	Phenol		Printing	Inks
Raffinate		Phthalic Anhydride			
Gas Oil		Terephthalic Acid			
Carbon Black Oil	Carbon Black		Surface active agents	Soaps and detergents	Household products
Crude Oil					Industrial cleaners
			Additives	Petroleum refining	Gasoline
				Transportation	Lubricants
			Synthetic rubber	Tires	Tires
				Fabricated rubber	Belting, hose
					Footwear
			Fertilizers and agricultural chemicals	Agriculture	Foodstuffs

Source: Adapted from U.S., Dept. of Commerce, Industry & Trade Admin., 1980.

[a] These lists are intended to be representative of types rather than inclusive.

reflect a change in policy, namely the recognition that new radical technologies may help western economies out of stagnation.

With respect to the chemical industry it is very probable that the enforcement of the TOSCA will require more R&D investment for the introduction of new products and for the development of processes which will be safer for its employees. This does not mean, however, that there will be a reduction in the inventive potential of the industry. New products and processes with adverse health effects have not always been beneficial in the long run to the firms that invented them. Thalidomide, for example, led the Distillers Company in Britain to sell all its chemical interests to the British Petroleum Company. According to the TOSCA, control of new chemicals entering the market will help to ensure that inventive activities are directed toward safer products. The progress of industry in energy conservation, pollution control, biodegradable detergents, nonpolluting insecticides, and the development of pharmaceuticals with fewer side effects are indications of the R&D and inventive potential of the industry and that TOSCA goals are achievable. This potential may be used to create less hazardous products and processes in the future.

7.4 SUMMARY

The chemical industry is the largest manufacturing industry in the Sunbelt. It is concentrated in Texas and Louisiana which contain a very large proportion of the U.S. petrochemical industry, in Tennessee and Kentucky which provide a wide variety of chemicals, and in Florida which specializes in phosphates and other fertilizers. Most other states also show important growth in their shipments of chemicals. There is good evidence that the growth will continue in the foreseeable future, and that the chemical industry will become an important driving force for the economic development of the South.

Increased environmental concerns that may be expected as a result of the projected doubling of the capacity of the chemical industry in the next 20 to 30 years are the following:

- Meeting social infrastructure requirements (housing, schools, roads, etc.) in areas of rapid urban development around the large concentrations of chemical plants along the Gulf Coast;
- Cumulative effects of gaseous and liquid effluents on air and fresh water quality in and around dense concentrations of chemical plants;

- Traffic congestion and hazards from toxic chemicals on roads and navigable rivers due to the increasing volume of chemical shipments; and
- Shortage in hazardous waste management facilities and potential risks from substandard facilities.

Measures which will help to reduce the probability of the above adverse impacts occurring are:

- Long term planning by government agencies and industry for the growth of existing centers of chemical manufacturing;
- Long term planning of federal, state, and local government agencies and industry for the identification and development of new sites for chemical industry growth along the Gulf and South Atlantic coasts;
- Encouragment in terms of policies and incentives by state and local governments for the development of hazardous waste management industries and for the regulation and monitoring of hazardous waste disposal sites;
- Cooperation between government and the chemical industry in the implementation of the TOSCA and the RCRA; and
- Federal policies to encourage the industry to maintain its efforts in research, development, and innovation, especially those related to reducing environmental risks.

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CHAPTER 8

THE TEXTILE INDUSTRY

HIGHLIGHTS

- Status and Trends

  1. The textile industry is highly diversified, with over 7,000 plants in 48 states, employing approximately 900,000 people, and 1980 industry shipments valued at 51 billion dollars.

  2. Although the textile industry is characterized by a low-to-moderate growth rate, it plays an important role in the giant fiber/textile/apparel industry complex which is the nations largest industrial employer.

  3. Although cotton historically has been the largest raw material supplier, synthetic fibers, supplied primarily from the petrochemical industry, now account for approximately 75 percent of total fiber consumption.

  4. The textile industry utilizes many different fibers, processes and chemicals which produce a highly variable wasteload. This increases the difficulty of effectively measuring and controlling any adverse environmental or human health impacts.

- Geographic Areas

  5. The textile industry is highly concentrated in Region 4 which accounts for over 68 percent of total industry employment and 66 percent of total industry earnings.

  6. The industry is further concentrated within Region 4 in North Carolina, South Carolina, and Georgia. In each of these states, textiles account for ar least 20 percent of total manufacturing in both employment and earnings.

  7. The vast majority of the 7,000 plus textile plants are located in nonmetropolitan communities where they are often the major local employer.

- Key Problems and Issues

8. Water pollution is an important environmental problem faced by the textile industry. Effluent discharges are often visible, as dye concentrations in some states are not regulated. One potential problem is the increasing use of process chemicals exhibiting some biodegradation resistance.

9. In some locations, textile facilities account for a large proportion of station point source hydrocarbon emissions.

10. The geographic concentration of the industry magnifies the significance of any adverse impact economically and environmentally associated with textile operations.

CHAPTER 8

THE TEXTILE INDUSTRY

8.1 INTRODUCTION

The U.S. textile industry is highly diversified, with over 7,000 plants processing a variety of fibers and fabrics into a multitude of end-products. Representing 69 percent of total industry employment, Region 4 is the textile manufacturing center of the United States. The industry is further concentrated in North Carolina, South Carolina, and Georgia. Because of its concentrated nature, the textile industry has significant potential to affect the economic and environmental characteristics of the areas in which it is located.

The industry is a large employer of semiskilled production workers representing approximately 4 percent of the nation's manufacturing labor force (American Textile Manufacturers Institute, 1982). Since the industry is divided into separate functions and dispersed in rural communities, individual textile mills are often the major employer in many small nonmetropolitan communities. Employee earnings in textiles is also high as a percentage of total manufacturing earnings in the key textile states of the Carolinas and Georgia.

The industry continually experiences the introduction of new fibers, finishes, and chemicals which combine to yield highly variable waste characteristics. In addition, the industry increasingly uses synthetic fibers, polymers, and finishes purposely designed to resist natural biodegradation processes and therefore, be more durable and longer-lasting. Most of these product changes are associated with wastes that degrade in treatment systems, but there is uncertainty about human health risks associated with these chemicals and processses.

The industry consists of a few large integrated complexes and numerous small specialized operations which perform one or more steps of a particular manufacturing process before transferring the product to another plant where further processing is conducted. Thus, wasteload, both the type and concentration, can differ greatly among plants and processes. This introduces uncertainties and difficulties in analyzing potential environmental impacts, integrating knowledge concerning common characteristics, and utilizing uniform data collection practices. All of these contribute to the regulatory and legal problems associated with proper definition and implementation of environmental controls within the industry.

8.2 CURRENT STATUS AND FUTURE TRENDS

8.2.1 Industry Overview

The U.S. textile industry is a component of the fiber/textile/apparel industry complex which is the nations's largest industrial employer (U.S., Dept. of Commerce, Ind. & Trade Admin., 1981). Together these industries employ one out of every eight Americans with manufacturing jobs and are the largest employers of women and minority workers in manufacturing. The textile industry has grown to a point where there are over 7,000 plants in 48 states, employing approximately 900,000 people, with 1980 industry shipments valued at 51 billion dollars (U.S., Dept. of Commerce, Ind. & Trade Admin., 1981).

Tables 8-1 and 8-2 contain projections for industry employment and earnings through the year 2010 for regions 4 and 6. These projections are based upon recent Bureau of Economic Affairs (BEA) data. Region 4 accounts for over 68 percent of total industry employment and 66 percent of total industry income. Within Region 4, North Carolina represents by far the largest concentration, with South Carolina close behind, followed by Georgia and Florida which are projected to increase slightly. On the other hand, Region 6 contains only a small portion of the textile industry, but is projected to add more total employees than Region 4 during the period.

Also illustrated in the tables is that total industry employment is projected to peak at 906,000 persons in 1985 while industry earnings continue to climb through 2010. Although not clear from the data, possible explanations for this variance could include:

1. Increased productivity through modernization of equipment and technology;

2. Capacity underutilization existing in the early periods; and

3. Increased consolidation within the industry through acquisition of small companies by larger firms.

The textile industry depends entirely on the cotton and wool industries (natural fibers) and the petrochemical industry (synthetic fibers) for their input of raw materials. Although cotton has historically been the largest supplier, synthetic fibers have

TABLE 8-1: TEXTILE INDUSTRY (SIC 22) EMPLOYMENT

Region/State	1978	1990	2000	2010
Region 4				
Alabama	45,714	44,181	43,588	43,079
Florida	4,191	6,303	7,629	8,525
Georgia	25,984	133,653	134,690	135,008
Kentucky	7,250	8,121	8,907	9,408
Mississippi	6,492	7,219	7,875	8,295
North Carolina	53,561	251,589	249,180	246,677
South Carolina	43,825	143,703	145,642	146,527
Tennessee	28,892	26,765	25,299	24,280
Total	15,909	621,534	622,810	621,799
Percent of U.S. Total	69	69	70	70
Region 6				
Arkansas	4,229	4,323	4,382	4,409
Louisiana	--	4,418	5,251	5,814
New Mexico	2,974	4,084	4,836	5,452
Oklahoma	1,640	1,921	1,972	2,001
Texas	6,590	6,181	5,920	5,734
Total	15,433	20,927	22,361	23,410
Percent of U.S. Total	2	2	3	3

Source: Data calculated from U.S., Dept. of Commerce, BEA, 1980.

taken over the leadership during the past decade. For example, the total fiber consumption breakdown for 1979 and 1980 was: (1) synthetic fibers, 75 percent; (2) cotton, 24 percent; and (3) wool, 1 percent.

Textile plants range from highly integrated manufacturing complexes that perform many different types of fiber processing to small contract plants that process goods owned by other producers (Meyer, 1980). However, the majority of plants perform only one or two types of processing operations and the ownership is often confined to members of one family. This high degree of fragmentation is illustrated by the largest 50 companies that account for approximately 50 percent of total industry sales.

TABLE 8-2: TEXTILE INDUSTRY (SIC 22) EARNINGS
(millions of constant 1972 dollars)

Region/State	1978	1990	2000	2010
Region 4				
Alabama	315.6	397.0	488.3	599.8
Florida	26.8	51.5	76.9	106.0
Georgia	911.8	1,257.2	1,579.1	1,966.9
Kentucky	46.1	69.9	100.3	135.2
Mississippi	39.4	57.4	79.0	104.1
North Carolina	1,759.2	2,295.7	2,843.5	3,506.0
South Carolina	1,101.2	1,425.9	1,792.1	2,233.0
Tennessee	191.2	225.3	262.8	311.4
Total	4,391.3	5,779.9	7,222.0	8,962.4
Percent of U.S. Total	67	68	69	70
Region 6				
Arkansas	31.2	41.1	51.9	65.0
Louisiana	--	37.6	59.8	85.4
New Mexico	5.6	10.1	13.3	17.1
Oklahoma	10.3	16.5	21.8	28.1
Texas	46.8	56.5	68.6	83.4
Total	93.9	161.8	215.4	279.0
Percent of U.S. Total	1	2	2	2

Source: Data calculated from U.S., Dept. of Commerce, BEA. 1980.

8.2.2 Key Economic Factors

Internationally, textile manufacturing has historically been among the first industries to be established in developing countries. The industry's high requirement for semiskilled labor usually matches well with the availability of labor in these countries. However, as a nation prospers and labor costs increase, its textile industry becomes vulnerable to imports from less developed nations (Cooper, 1978). Due to the highly concentrated nature of the industry in the U.S., any economic decline in this industry could severly affect the economy of several states, namely North Carolina, South Carolina, and Georgia. Tables 8-3 and 8-4 are illustrative of the important role played by the textile industry in these three states. Although the trend is downward, the percentages projected for 2010 are still significant.

TABLE 8-3: INDUSTRY EMPLOYMENT--TEXTILES AS A PERCENT OF TOTAL MANUFACTURING

State	1978	1990	2000	2010
North Carolina	31	26	24	23
South Carolina	36	30	27	25
Georgia	24	22	21	20

Source: Data calculated from U.S., Dept. of Commerce, BEA, 1980.

TABLE 8-4: INDUSTRY EARNINGS--TEXTILES AS A PERCENT OF TOTAL MANUFACTURING

State	1978	1990	2000	2010
North Carolina	28	22	20	19
South Carolina	34	26	24	22
Georgia	21	19	18	17

Source: Data calculated from U.S., Dept. of Commerce, BEA, 1980.

In the U.S., the textile industry is characterized by a low-to-moderate growth rate and has been referred to as the "sunset industry" due to the maturity of the industry. However, during the past three to five years, the industry has benefitted from strong demand in U.S. markets and an accelerating demand for exports. The primary reasons relate to the close association between the economic vitality of the nation and that of the industry. For example, in 1979 the keys to the increasing export demand were: (1) moderately rising U.S. textile prices compared to more rapidly accelerating prices in other countries; (2) a declining dollar in foreign exchange markets; (3) a recessionary domestic market; and (4) the dampening effect of all of the above on demand for imports (Meyer 1980). However, these types of economic forces are dynamic and can change dramatically over short periods of time. Thus, any short-term increase in the industry's growth rate deserves further analysis of some of its key economic factors to determine the effect on long-term trends.

The primary cost elements associated with the textile industry include fiber consumption, labor, equipment modernization, energy, and process chemicals.

1. Fiber Consumption: Synthetic fibers are derived from petroleum and are highly sensitive to increased prices in the petroleum industry. A recent study by Arthur D. Little, Inc. forecasts an increase in the price of petroleum-based fibers by 55 to 110 percent by the mid1980's, based on the increased cost of imported oil (Denham, 1980).

2. Labor: For years, textile industry workers have received much lower wages than workers in other industries. This could change drastically as union activity steps up as a result of an agreement signed on October 19, 1980, by officers of the J. P. Stevens Company and the Amalgamated Clothing and Textile Workers Union ("Ripples Spreading," 1980). This represents the first collective bargaining agreement granted by a large textile manufacturer in the industry's history.

3. Equipment Modernization: A number of technological advances in the textile industry over the past several years have made it more capital intensive. For example, the industry invested an estimated $1.16 billion during 1979 and $1.62 billion in 1980 for new plants and equipment. These amounted to annual increases of 12 percent and 8 percent, respectively (Stodden, 1980 and Shockley, 1981). Although capital expenditures are rising, the major portion will go for modernization and operating improvements rather than for expansion.

4. Energy: Energy requirements vary considerably among textile facilities based upon the type of fiber processed,

type of operations, degree of mechanization in the mill, and the climate of the mill location (U.S., EPA, 1974a). For example, several polyester fabrics are high in energy costs due to the mechanical processes required in the finishing of the product. Thus, pricing on these fabrics will necessarily reflect any increase in energy costs. Industry sources indicate that energy costs in general have risen by some 250 percent over the past 8 years despite active programs to reduce consumption. Breaking it down by energy type, electricity costs rose by 200 percent and costs of natural gas by almost 350 percent ("Soaring Energy Costs," 1981).

5. Process Chemicals: Many different chemicals are used during the various types and stages of textile processing to add some required or desirable quality to the raw fiber and/or finished product. The economic impact of process chemicals is twofold: first, the rising costs of the chemicals themselves; more important, however, are the wastewater management costs associated with these chemicals. It has been estimated that over 90 percent of the pollution load of textile wastes is contributed by the process chemicals (Jones, 1973).

8.3 ENVIRONMENTAL CONCERNS

Few generalizations can really be made about textile plant emissions, effluents, or solid wastes since they differ so much from plant to plant (Bahorsky, 1974). This is due to the variety of dyes, chemicals, lint, and other materials which are removed from textile fibers resulting in complex waste products and mixtures that vary according to the process operation and equipment used. Thus, consideration must be given to the chemicals used, fibers processed, fabric weight, type of processing performed, equipment used, and even the arrangement of the equipment (Bahorsky 1974).

8.3.1 Water Related Concerns

Several mechanical operations are required to convert textile fibers into fabrics. Typically, the fibers are combined into yarns, and then are woven or knitted into fabrics which are then treated with special finishes. In this transformation procedure, two types of processes are used: wet and dry. The wastewater effluent problems stem mostly from the wet processes which are used to desize, wash, dye, and finish the textile fabric. Estimates of water use by the textile industry are in the range of 100 to 125 billion gallons per year. About 2,000 mills have wet operations of some kind, and 75 to 85 percent of the water use is concentrated in 300 to 350 relatively large plants (Lockwood Greene, 1975).

The major pollution sources in textile wastewaters are (1) naturally occurring dirts, salts, oils and greases on cotton and wool; (2) fibers removed by chemicals and mechanical action during processing; and (3) chemicals added and/or removed during the many different process operations (Jones, 1973). Current treatment requirements of "Best Practicable Control Technology" (see Chapter 14) have been established for textile mills (which vary according to the many mill types). However, discharge permits are established by states and can exceed the standards in some instances. Although most mills are in compliance, some mills vary in their ability to comply with permit standards (North Carolina Water Resource Research Institute, 1982). Some states, such as North Carolina, have not established standards for dye discharges so that effluents from textile mills are frequently colored (North Carolina, Department of Natural Resources and Community Development, 1982). Specific examples of the characteristics of in-plant process water include (Clemson University, 1971):

1. pH: The processes of dyeing, bleaching, and adding of certain finishes require aqueous baths of varying alkaline and acid content. Thus, some form of neutralization is necessary to ensure discharges within the required range;

2. Temperature: Large amounts of water are used which are heated above 100°F. Such temperatures are above any state's standards and must be controlled;

3. Color: The dyeing process produces an effluent that can impart an unsightly color if discharged directly to receiving streams;

4. Sludge Deposits: Textile wastes contain inorganic chemicals, fiber, and other insoluable materials which must be controlled;

5. Dissolved Oxygen: Many of the process chemicals used in dyeing and finishing are high in biochemical oxygen demand which is reduced to meet permit standards; and

6. Toxic Materials: A number of chemical finishes and dyes contain chromium and phenolic compounds which are toxic to the aquatic environment.

Most of the naturally occurring waste effluents are biodegradable. However, many of the synthetic fibers, polymers, and finishes are more resistant to biological degradation.

The human health risk of the chemicals used in the dyeing and finishing processes is uncertain. The review process for new chemicals required by the Toxic Substances Control Act (TSCA) addresses this problem. TSCA requires that new chemicals be tested for their possible adverse health effect before commercialization. In addition, the U.S. is working within the framework of the Organization of Economic Cooperation and Development in cooperation with other member countries to establish common testing procedures for new chemicals. It is expected that when testing procedures are established and standardized, chemicals which are presently not affected by TSCA (i.e., those which were produced before TSCA took effect) will also be tested for their potential adverse health effects.

8.3.2 Air Related Concerns

Air pollution from textile mills consists of particulates such as dust and lint and hydrocarbons from the process chemicals (U.S., EPA, 1976). Hydrocarbon emissions in North and South Carolina accounted for 5,112 and 11,480 tons per year respectively in 1977 (U.S., EPA, 1980). On a statewide basis this represents 5 percent and 22 percent of the total point source hydrocarbon emissions. However, in some locations such as metropolitan Charlotte, textile mills account for 66 percent of the total hydrocarbon emissions (U.S., EPA, 1980). Solvent processing of knit fabrics produces the major air quality threat due to the potential emissions of chlorinated hydrocarbons, trichlorethene and perchlorethene. This is largely an occupational safety threat and is limited to the immediate vicinity within the plant where these chemicals are being used. In addition, recovery of these chemicals is important for economic reasons, and the available technology incorporates solvent recovery as part of the process.

A significant industrial health problem associated with the textile industry is the occupational hazard linked to long-term exposure to cotton dust. The term most used is "brown lung", or byssinosis, which is a respiratory disease characterized by shortness of breath, coughing and tightness of the chest. In response to this potential health hazard, the Occupational Safety and Health Administration (OSHA) has developed standards designed to protect textile plant workers from brown lung disease. The industry has resisted the implementation of these standards based on cost/benefit relationships. However, a recent U.S. Supreme Court decision upheld the OSHA standards saying such a regulation could be challenged only when the standards might not be technically achievable or when its expense might jeopardize economic health of the affected industry ("Court Rebuffs," 1981).

8.3.3 Solid Wastes

At one time, 3.6 percent by weight (dry basis) of the industry's total process wastes for land disposal was considered to be potentially hazardous (Cooper, 1978) (also see Chapter 15). The two major categories of this potentially hazardous waste are heavy metals and dyestuffs. Specific components include chemicals used in dyeing and finishing operations, such as acids, alkalies, bleaches, adhesives and polymers, crosslinking agents, carbonizing agents (wool), conditioners, catalysts, detergents, dye carriers, chemical finishes (including flame retardants), and solvents (Cooper, 1978).

Table 8-5 contains 1974 estimates for solid wastes for North Carolina, South Carolina, and Georgia combined, again demonstrating the concentrated nature of the industry (Versar, 1976).

TABLE 8-5: ESTIMATES OF TEXTILE SOLID WASTE, 1974

Category	North Carolina, South Carolina, Georgia (metric tons)	Percent of Total Textile Industry
Estimated quantities of total wastes	119,092	38
Estimated quantities of potentially hazardous dye and chemical containing wastes	4,470	45
Estimated quantities of total potentially hazardous wastewater treatment sludge	7,401	19

Source: Versar, 1976.

The criteria used for determining the concentration at which textile wastes were considered potentially hazardous were the drinking water standards for specific heavy metals and total organics. However, based on the more recent results of leachate extractions and whole sludge analyses from industry studies, EPA did not include textile sludge wastes on the hazardous waste list of the Resource Conservation and Recovery Act regulations published May 19, 1980 (Shockley, 1981).

8.4 SUMMARY

Most of the environmental uncertainties associated with the textile industry are due to two conditions: (1) the variation in waste loads among individual textile processing plants; (2) the use of chemicals of which little is known concerning their potential adverse human health effects. As a result, these conditons make difficult broad generalizations regarding the potential environmental threat posed by the textile industry.

The high geographic concentration of the industry in Region 4 and more specifically, the Carolinas and Georgia, magnify the significance of these concerns. Not only are environmental impacts of effluents, hydrocarbon emissions and solid wastes concentrated, but an adverse shift in some of the industry's key economic factors could have severe implications for a large workforce concentrated in those three states.

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CHAPTER 9

AGRICULTURAL DEVELOPMENT AND FOREST MANAGEMENT

HIGHLIGHTS

- Status and Trends

1. Agriculture and forestry are locally major economic activities with secondary economic benefits. Cattle ranching is the major agricultural product in the Southern Plains, soybeans are the major product in the Delta states, and a range of products, including tobacco, broilers, and oranges dominate the Southeast.

2. Agricultural crops have changed dramatically in the past. For example, although cotton has declined region wide, it continues to be important in the Delta and Southern Plains states. Soybeans, wheat, and corn are projected to continue major increases in acreage planted and earnings.

3. Insecticide application in the South has shifted from organochlorine to organophosphate compounds and the total amount applied has apparently stabilized in the South. Herbicide application continues to increase dramatically.

- Geographic Areas

4. Recent cotton farming practices in Texas and Oklahoma have allowed major reductions in insecticide use. The dramatic reduction in insecticide applications is apparently due to the varieties of cotton cultivated and specific pest management practices.

5. Application of insecticide and herbicide is greatest in the Delta states and may continue to increase in these states and in the Southeast.

6. Bottomland hardwoods stands continue to be reduced in Delta and Southeastern states, contributing to a further reduction in hardwood acreage and an increase in soybean and other crop acreage.

- Key Problems and Issues

7. Reduction in the physical availability of ground water is likely to result in changed agriculture practices in parts of Texas, Oklahoma, and New Mexico. Regional water availability may be a major problem as more farmers seek to irrigate their fields.

8. Farm management practices are resulting in increased herbicide applications. This increase is likely to continue to be an environmental issue.

9. Large acreages of privately managed southern forest held by relatively small land owners appear to experience cutting rates that exceed replacement. Erosion from access roads and harvesting practices may also be a potential environmental issue.

CHAPTER 9

AGRICULTURAL DEVELOPMENT AND FOREST MANAGEMENT

9.1 INTRODUCTION

Agriculture and forestry are significant driving forces within the Sunbelt due to their use of large areas of land and their multiplying economic effect within the region. In 1978 agriculture directly provided 3 percent of total industrial earnings in the region, and lumber, paper, and allied products accounted for 2 percent. These figures, however, belie the importance of farming and forestry, for they are basic industries supporting a large network of related industries and commercial services. For every million dollars worth of grain produced by 30 grain farmers, 32 other jobs (in wholesale and retail trade, transportation, chemicals, business services, machine manufacturing, etc.) are created (Batie and Healy, 1980). In addition, earnings from forestry and agriculture in the Sunbelt comprise an important share of the national earnings in agriculture and forestry. In 1978, the Sunbelt made up 29 percent of the total U.S. agricultural earnings and 30 percent of the total U.S. lumber products earnings. Much of the millions of metric tons of soybeans, wheat, rice, and cotton that are exported from the U.S. to the world commodity market is produced in the South.

Rising costs in agricultural inputs, such as energy, water, machinery, and chemicals, along with losses in soil productivity, may force important changes in farming and management practices that will impact the South's environment. Continued demand for grain exports and lumber, as well as expanding urbanization may increase pressure on the South's reserves of potential cropland and productive forests.

This chapter discusses the current status, probable future developments, and potential environmental and health impacts of agriculture and forestry in the Sunbelt. Because of differing production factors as well as different environmental impacts, agriculture and forestry are discussed separately.

9.2 AGRICULTURAL DEVELOPMENT

A "golden age" of agricultural productivity occurred over the last 30 years, particularly in the 1950's and 1960's. In general, agricultural production in those years was enhanced by good climate, research advances, improvements in mechanization and technology, and inexpensive and abundant land, energy, and water (Batie and Healy, 1980). The development of hybrids and effective fertilizers and pesticides facilitated the growth of large-scale monoculture, in which large acreages are devoted to single crop production. In addition, irrigation opened millions of acres of naturally arid land to the cultivation of high-value, water-intensive crops, such as alfalfa and corn.

Consequently, the annual growth rate of U.S. agricultural output increased from 1.7 percent in the period 1950 to 1965 to 2.2 percent between 1965 and 1979. Labor productivity has been growing by 5.5 percent annually since 1970, while in the rest of the economy it has increased by only 1.5 percent. However, some projections anticipate a growth in agricultural output closer to 1 percent annually in the future (Batie and Healy, 1980, p. 138). In fact, land productivity or output per unit of land has dropped from 2.6 percent growth rate in 1950 to 1.2 percent in 1979. The status, trends, and environmental issues associated with the major agricultural crops and products are discussed below.

9.2.1 Current Status

A. Land Use

A large proportion of land in the study area is used for agricultural purposes--slightly over 80 percent for both federal regions (Table 9-1). This agricultural land includes cropland, pasture, rangeland, forest, and other land in farms. The Sunbelt contains 24 percent of the nation's cropland, 41 percent of its pasture and range, 43 percent of its forests, and 26 percent of the total U.S. land.[1]

While both regions have similar proportions of cropland the larger Region 6 has 17 million acres more. Actual acreages of pasture land in the two regions are similar, with 31.4 million acres in Region 6. However, the two regions differ significantly in both proportionate and actual rangeland and forest acreage. Florida is the only state in Region 4 with any significant rangeland (see Chapter 12). The Sunbelt contains about 56 million acres or 7 percent of federally owned land in the country. Only

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[1] Except for total land area, these percentages are for all nonfederally owned land.

TABLE 9-1: AGRICULTURAL LAND USE IN REGIONS 4 AND 6, 1977[a]
(thousands of acres)

State	Cropland	Pasture	Range	Forest	Other Land in Farms	Total Agricultural lands	Total Land Area	Percentage Agricultural lands
Region 4								
Alabama	4,499	4,122	0	19,792	327	28,740	32,434	89
Florida	3,189	5,483	3,017	12,140	355	24,184	34,473	70
Georgia	6,487	3,234	0	21,566	283	31,570	37,160	85
Kentucky	5,428	5,735	0	10,648	412	22,223	25,399	87
Mississippi	7,302	4,041	30	14,412	338	26,123	30,225	86
North Carolina	6,197	2,030	0	16,813	442	25,482	31,208	82
South Carolina	3,331	1,242	0	10,770	154	15,497	19,301	80
Tennessee	4,928	5,474	0	11,638	351	22,391	26,403	85
Total	41,361	31,361	3,047	117,779	2,662	196,210	236,603	83
Region 6								
Arkansas	7,990	5,628	248	14,072	296	28,234	33,291	85
Louisiana	5,899	2,945	326	12,595	220	21,985	28,746	77
New Mexico	2,282	382	42,096	3,426	267	48,453	77,720	62
Oklahoma	11,783	8,713	14,566	4,931	356	40,349	43,920	92
Texas	30,439	18,768	95,401	9,240	1,493	155,341	167,782	93
Total	58,393	36,436	152,637	44,264	2,632	294,362	351,459	84
Sunbelt Total	99,754	67,797	155,684	162,043	5,294	490,572	588,062	83
U.S. Total	412,970	132,706	414,073	376,135	23,006	1,358,890	2,262,683	60

Source: Calculated from Hidlebaugh, 1981.

[a] For a more extensive description of land use categories (e.g., forest and range) see Chapter 12.

a small percentage of these federal lands are leased for crop or grazing purposes (McGill, Hidlebaugh and Yovino, 1981).

B. Major Crops and Products

In the Sunbelt, agriculture traditionally has consisted of livestock and wheat ranching in the West, mixed farming in Appalachian areas, and cotton and tobacco farming in the Southeast. On the basis of cash receipts livestock production is most important within the study area. Cattle ranching takes place throughout the area, but most predominantly in Texas, Oklahoma, and Florida; sheep are raised in Texas; concentrations of large custom cattle feedlots exist in eastern New Mexico and in the Texas and Oklahoma panhandles; swine are raised in North Carolina, Kentucky, and Georgia; and dairy farms are located throughout the study area (with very few in New Mexico). Poultry production is particularly important in the South, with Arkansas, Alabama, Mississippi, Georgia, Florida, and North Carolina leading producers. In some states, cash receipts from the sale of livestock and livestock products are considerably larger than those from the sale of crops (Table 9-2). In each of the states in the Sunbelt, some form of livestock is in the top three commodities.

While the pasture and rangeland that support livestock occupy a large proportion of land in the study area, this land is managed much less intensively than cropland and requires neither the frequent application of chemicals nor the compacting action on the soil by heavy machinery. Most importantly, it does not require seeding or harvesting, which exposes soils thereby increasing erosion and runoff.

In the past forty years marked changes have occurred in cropland production in the South. For example, in 1940 nine southern states (Georgia, Alabama, North and South Carolina, Tennessee, Mississippi, Arkansas, Missouri, and Louisiana) produced 60 percent of the U.S. total cotton; by 1975 these nine states produced only half as much, representing 37 percent of the U.S. total. This decline can be attributed to a lowered export demand as use of synthetic fibers grew, and to the development of larger and more efficient farms in the western portion of the Sunbelt.

In contrast, soybean production has expanded dramatically--from 5.4 million bushels in 1940 (7 percent of U.S. total) to 523 million bushels in 1975 (33 percent of the U.S. total) (Fornari, 1979). By 1981 more cropland was planted to soybeans than to any other crop in the Sunbelt. Arkansas, Louisiana, and Mississippi are the prime soybean states--large areas of bottomland hardwood forest in these states have been cleared and planted to soybeans in the last two decades.

TABLE 9-2: CASH RECEIPTS FROM FARM MARKETING, 1979
(millions of dollars)

State	Livestock and Livestock Products	Crops	Total	Leading Commodities by Cash Receipts
Region 4				
Alabama	1,282	771	2,053	Broilers, cattle, soybeans
Florida	995	2,898	3,893	Oranges, cattle, greenhouse
Georgia	1,622	1,340	2,962	Broilers, peanuts, soybeans
Kentucky	914	1,141	2,055	Tobacco, cattle, soybeans
Mississippi	892	1,192	2,084	Soybeans, cotton, cattle
North Carolina	1,424	1,974	3,397	Tobacco, broilers, hogs
South Carolina	374	685	1,060	Soybeans, tobacco, cattle
Tennessee	955	824	1,779	Soybeans, cattle, dairy
Total	8,458	10,825	19,283	
Region 6				
Arkansas	1,562	1,600	3,162	Soybeans, broilers, rice
Louisiana	527	1,111	1,638	Soybeans, cattle, rice
New Mexico	881	240	1,121	Cattle, dairy products, hay
Oklahoma	2,103	1,127	3,230	Cattle, wheat, cotton
Texas	6,092	3,879	9,971	Cattle, cotton, wheat
Total	11,165	7,957	19,122	
Sunbelt Total	20,623	18,782	38,405	
U.S. Total	68,639	62,820	131,349	

Source: USDA, 1980, pp. 32-33.

Wheat production has increased dramatically in the nation. The South has increased its wheat acreage from 15 to 23 million acres in just two years. Its share of wheat production grew from 22 percent in 1979 to 27 percent in 1981.

As shown in Table 9-3, in 1981 the Sunbelt planted more than four-fifths of the U.S. acreage in cotton, rice, peanuts, tobacco, and sugar cane. These crops tend to be localized within particular areas of the South. Rice, for example, is only grown in Arkansas, Louisiana, Texas, and Mississippi. In contrast corn, sorghum, wheat, and soybeans are planted throughout the region, covering over 65 million acres or 78 percent of the acreage planted to the nine major field crops in 1981.

In the western portion of the study area sorghum and wheat, crops well suited to growing in semiarid conditions, are the major crops; large acreages of cotton are also grown in this area. In 1981 Texas and Oklahoma grew 34 percent of the national sorghum acreage plus 18 percent of the total U.S. wheat acreage, while Texas alone had over half the U.S. acreage in cotton. Other small grains, hay, forage crops, and rangeland provide the basis for cattle ranching in the area.

In the Delta states (Mississippi, Louisiana, and Arkansas), the principal crops are soybeans, wheat, and cotton. Arkansas and Mississippi are also two of the top five states in the nation in poultry production. Farther east in the study area soybeans, corn, peanuts, and tobacco are more important crops. Florida grows far less of any of the major crops (except sugar cane) since it devotes large acreages to citrus and winter vegetable production.

C. Factors in Crop Production

The last decade of growing export demand has witnessed an increase in cropland as well as an increase in the use of fertilizers, pesticides, and irrigation waters. This section discusses the current use of these inputs by southern farmers, as well as the influence of export demand on the South's agricultural industry.

1. Fertilizer Use

The use of fertilizers in the Sunbelt has increased yields per acre, but it is also a significant contributor to nonpoint source pollution. West-central Oklahoma, the panhandles of Texas and Oklahoma, and the Delta region are areas of particularly high fertilizer use. Between 1965 and 1978 subregions within the South increased their consumption from 39 to 75 percent as shown in Table 9-4.

TABLE 9-3: ACREAGE PLANTED TO MAJOR CROPS, 1981
(thousands of acres)

State	Soybeans	Wheat	Cotton	Corn	Sorghum	Rice	Peanuts	Tobacco[a]	Sugar Cane[a]
Region 4									
Alabama	2,100	650	330	580	75	--	211	1	--
Florida	475	--	13	451	--	--	69	10	340
Georgia	2,300	1,150	170	1,600	200	--	560	53	--
Kentucky	1,750	810	--	1,680	41	--	--	237	--
Mississippi	3,800	650	1,300	190	80	340	8	--	--
North Carolina	1,920	440	79	2,000	110	--	172	358	--
South Carolina	1,600	400	120	645	35	--	16	67	--
Tennessee	2,450	1,025	330	805	90	--	--	75	--
Total	16,395	5,125	2,342	7,951	631	340	1,037	801	340
Region 6									
Arkansas	4,550	1,750	620	65	330	1,600	--	--	--
Louisiana	3,180	310	640	45	50	650	--	--	260
New Mexico	--	700	147	109	306	--	10	--	--
Oklahoma	280	7,900	670	115	700	--	122	--	--
Texas	700	7,800	7,418	1,300	4,800	590	290	--	38
Total	8,710	18,460	9,495	1,634	6,186	2,840	422	--	298
Sunbelt Total	25,105	23,585	11,837	9,585	6,817	3,180	1,459	801	638
Percent of U.S.	37	27	83	11	42	83	93	85	86
U.S. Total	68,540	88,792	14,203	84,627	16,143	3,842	1,563	946	744

Source: USDA, Statistical Reporting Service, Crop Reporting Board, 1981.

[a] For tobacco and sugar cane, figures represent estimates of area to be harvested.

TABLE 9-4: FERTILIZERS APPLIED TO HARVESTED ACREAGE[a]

Region[a]	1965	1970	1975	1978	% Change 1965-78
South Atlantic					
Acres harvested	15,116	13,873	16,330	16,633	+ 10
Fertilizer (lb/acre)	229	300	261	289	+ 26
(thousands of tons)	1,731	2,081	2,131	2,406	+ 39
East South-central					
Acres harvested	15,068	14,964	17,993	20,240	+ 34
Fertilizer (lb/acre)	135	162	142	153	+ 12
(thousands of tons)	1,015	1,210	1,274	1,550	+ 53
West South-central					
Acres harvested	38,012	38,151	44,660	42,325	+ 11
Fertilizer (lb/acre)	59	93	77	92	+ 56
(thousands of tons)	1,113	1,779	1,728	1,947	+ 75
United States					
Acres harvested	294,121	283,180	324,202	324,836	+ 10
Fertilizer (lb/acre)	75	113	108	127	+ 69
(thousands of tons)	10,985	16,068	17,571	20,599	+ 88

Source: Data compiled from Batie and Healy, 1980, pp. 101-2.

[a] The South Atlantic refers to Florida, Georgia, South Carolina, North Carolina, Virginia, Delaware, Maryland, West Virginia, and The District of Columbia. The East Southcentral region is Kentucky, Tennessee, Mississippi, and Alabama. The West Southcentral region is made up of Texas, Oklahoma, Arkansas, and Louisiana.

The amount of fertilizers applied reflects changes in the extent of harvested cropland within each region, as well as in the intensity of fertilizer use. Table 9-4 shows that per acre applications also increased from 1965 to 1978. Two southern regions, the South Atlantic and the East Southcentral started with higher than average application rates per acre in 1965. While application rates in these two regions did not increase as fast as in other regions, by 1978 they still were applying heavier amounts of fertilizer. In fact, the South Atlantic has the highest application rate in the nation.

Some of these patterns of regional variations in fertilizer use depend on the crops planted. As indicated earlier, the four major southern crops are soybeans, wheat, cotton, and corn. Corn and cotton also have the highest rates of fertilizer application in the U.S., at 103 and 78 pounds of nitrogen per acre (U.S., EPA, 1977). However, soybeans and wheat, two crops whose production has increased in recent years, have much smaller fertilizer requirements--only 15 and 46 pounds, respectively. Thus, the increase in soybean acreage has generally reduced the trend toward greater fertilizer use in the South.

2. Pesticide Use

The development and use of chemical pesticides since the 1940's has been one of the most important factors making U.S. agriculture efficient and productive. Pesticides is a general term that includes insecticides, herbicides, fungicides, and other miscellaneous pesticides such as fumigants, defoliants, dessicants, and plant growth regulators. These chemicals have accounted for at least 10 percent of the increase in farm output during the last 30 years (Wittwer, 1980). But because pesticides may affect many organisms, they can damage beneficial species of insects, plants, and wildlife; they may result in the build-up of genetic resistance in insects; and they may threaten human health. Nearly all farm pesticides are applied to crops; only 2 percent are applied to livestock (mostly to beef cattle) to control flies (Eichers et al., 1978). Southern farmers also make extensive use of fungicides and miscellaneous pesticides as well. Most of the 19.4 million pounds of fumigants used in the U.S. in 1976, for example, were applied to tobacco; nearly all of the 8.6 million pounds of defoliants and dessicants were used as cotton harvesting aids; and all of the 6.3 million pounds of plant growth regulators were applied to tobacco and peanuts.[1] Since cotton, tobacco, and peanuts are grown largely in the South, this area of the country receives a large proportion of the total miscellaneous pesticides applied to crops in the U.S.[2]

(a) Insecticides

Farmers use three major kinds of insecticides: organochlorines, organophosphates, and carbamates. The organochlorines, of which DDT and toxaphene are examples, are persistent, remaining active three to five years after application, and they also tend to accumulate in the food chain. The organophosphates and carbamates, which increasingly are used as substitutes for the organochlorines, are more short-lived. They are, however, toxic, and therefore represent a health hazard. In 1964 the South treated 9.2 million acres (mostly cotton) with 26.9 million pounds of DDT; this was 84 percent of all the DDT used in the nation. By 1976, however, use of DDT was no longer allowed. Instead, 31 million pounds of organophosphates along with 26 million pounds of toxaphene were used to control cotton pests.

In 1976 the South applied 86.3 million pounds of insecticide to its major field crops or 66 percent of the total used by U.S. farmers (Table 9-5). This, however, represented a decline in

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[1] The U.S. Department of Agriculture (USDA) estimates on pesticides application are disputed. The USDA surveys of pesticide use conducted in 1964, 1966, 1971, and 1976 are the most complete time series data on pesticides. Research on pesticides conducted by von Rumker et al. in 1975 found the 1971 USDA estimates were considerably and consistently lower than their own estimates. Total insecticide use estimated by USDA for 1971, for example, was 82.8 million pounds, while von Rumker estimated 135.6 million pounds. Thus, while the discussion in this section uses USDA reports, it is possible that absolute figures may be serious underestimates of actual pesticide use. The assumption is made, however, that error has been systematic and unidirectional for each survey, so that meaningful comparisons can be made of trends in usage over the years.

[2] The pesticide data is given by USDA agricultural regions. The regions that contain Sunbelt states are Appalachian (Kentucky, Tennessee, North Carolina, West Virginia, and Virginia), Southeast (Alabama, Georgia, South Carolina, and Florida), Delta (Arkansas, Louisiana, and Mississippi), and the Southern Plains (Texas and Oklahoma). About 20 percent of the acreage planted to major crops in the Appalachian region is in West Virginia and Virginia. Also, New Mexico is part of an eight state Mountain region which is not included in the following discussion. New Mexico has comparatively little cropland, however, so that its use of pesticides is relatively minor.

TABLE 9-5: INSECTICIDE USE ON MAJOR CROPS IN THE SOUTH[a] AND THE U.S.

(thousands of pounds)

Crop	South			U.S.		
	1964	1971	1976	1964	1971	1976
Corn	1,264	508	3,182	15,668	25,531	31,979
Cotton	73,100	70,512	59,787	78,022	73,357	64,139
Wheat[b]		1,444	4,650		1,712	7,236
Sorghum[b]		3,700	1,953		5,729	4,604
Soybeans	4,446	5,477	8,977	4,997	5,621	7,866
Tobacco	5,315	3,978	3,159	5,471	3,999	3,240
Peanuts[b]		5,990	2,439		5,993	2.439
Rice[b]		817	508		946	508
Other grains[b]		453	1,459		821	1,823
Alflafa, hay, and forage[b]		282	1,704		2,448	6,350
Pasture and range[b]		158	108		161	114
Subtotal[b]	(8,293)	(12,844)	(12,821)	(12,551)	(17,810)	(23,074)
Total	92,418	93,322	86,327	116,709	126,318	130,298
Percent of U.S. Total	79	74	66			

Sources: Data compiled from Eichers et al., 1968 and 1978; and Andrilenas, 1974.

[a] South is Region 4 including Virginia and West Virginia and Region 6, excluding New Mexico.

[b] 1964 data are aggregated, therefore comparable totals for these crops are given in parentheses.

insecticide use from 1964, when the South used 92.4 million pounds or 79 percent of all the insecticides used. The Mississippi Delta, the panhandles of Texas and Oklahoma, central Florida, the Gulf Coasts of Texas and Louisiana, and the coastal to central areas of North and South Carolina and Georgia apply insecticides to the largest acreages.[1]

There is considerable variation in the percentage of a crop that is treated by insecticides. About 90 percent of all cotton in the South is treated, while only about 25 percent of soybeans and corn is treated. Table 9-6 compares insecticide application rates for different crops in 1971 and 1976. The South consistently applied more pounds of insecticide per acre than did the United States as a whole.

The South, however, has cut its insecticide application rate nearly in half between 1971 and 1976 from 1.18 pounds per acre in 1971 to .63 in 1976. Large reductions were made in the amounts applied to the tobacco, peanut, and cotton crops. However some application rates increased on wheat, soybeans, other grains, and hays.

This reduction in insecticide use has not been uniform throughout the South, however. Table 9-7 compares insecticide use in 1971 and 1976 by the four U.S. Department of Agriculture (USDA) regions that most closely approximate the Sunbelt--Appalachian, Southeast, Delta, and Southern Plains[2]. In actual pounds used, the Delta and the Southeast states applied by far the most in both years, with over 30 million pounds each in 1976. Half the insecticide used in the nation goes on crops in these two USDA regions.[3]

Cotton is a key crop in understanding the general pattern of insecticide applications. The Southeast states apply two-thirds of their insecticide on cotton with the rest on soybeans and peanuts, while the Delta applies virtually all of its insecticide on

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[1] For the most part the insecticide applications in these states are to acreages of soybeans, cotton, corn, alfalfa, wheat, peanuts, and tobacco; and fruit and vegetable acreages in Florida.

[2] Appalachian includes Kentucky, Tennessee, North Carolina, West Virginia, and Virginia; Southeast is Alabama, Georgia, South Carolina, and Florida; Delta states are Arkansas, Louisiana, and Mississippi; Southern Plains is Texas and Oklahoma.

[3] The Appalachian and Southern Plains states apply far less insecticide and apply it more evenly over a larger number of crops (see Table 9-A1 in the Appendix for a complete breakdown by major crops).

TABLE 9-6: PESTICIDE APPLICATION RATES IN THE SOUTH[a] (pounds per acre)

Crop	1971 Insecticide	1971 Herbicide	1976 Insecticide	1976 Herbicide
Corn	.05	.94	.26	2.42
Cotton	6.53	1.64	5.93	1.60
Wheat	.13	.02	.27	.06
Sorghum	.37	.42	.21	.66
Soybeans	.36	.88	.48	1.59
Tobacco	5.22	NA	3.25	1.16
Peanuts	3.94	2.87	1.59	2.19
Rice	.55	4.77	.24	4.04
Other grain	.06	(b)	.32	.05
Alfalfa & hay	.02	.01	.14	.03
Pasture	(b)	.02	b	.01
Total South	.33	.21	.34	.39
Total South excluding pasture	1.18	.71	.63	1.08
U.S. Total excluding pasture	.41	.65	.38	1.07

NA = Not available.

Sources: Data calculated from Andrilenas, 1974 and 1975; and Eichers et al., 1978.

[a] South is Regions 4 and 6, including Virginia and West Virginia, but excluding New Mexico.

[b] Less than .01 pounds per acre.

TABLE 9-7: INSECTICIDE APPLLICATION RATES TO SELECTED MAJOR CROPS, BY REGION[a]
(pounds per acre)

Crop	Appalachian		Southeast		Delta		Southern Plains	
	1971	1976	1971	1976	1971	1976	1971	1976
Corn	.08	.17	.01	.22	.08	05	.07	.70
Cotton	5.55	8.02	19.49	21.98	9.63	9.77	1.80	.46
Wheat	(b)	.12	(b)	(b)	.16	(b)	.16	.31
Soybeans	.26	.19	1.01	1.66	.21	.02	.08	.24
Tobacco	4.01	2.77	10.79	5.70	--	--	--	--
Peanuts	3.92	4.17	4.76	1.28	.30	(b)	2.51	.59
Average all major field crops[c]	.51	.50	3.05	2.22	1.95	1.80	.50	.35
Total pounds used (thousand pounds)	8,705	9,548	35,667	30,124	31,812	33,653	16,980	12,893

Sources: Data calculated from Andrilenas, 1974 and 1975; and Eichers et al., 1978

[a] Appalachian includes Kentucky, Tennessee, North Carolina, West Virginia, and Virginia; Southeast is Alabama, Georgia, South Carolina, and Florida; Delta states are Arkansas, Louisiana, and Mississippi; Southern Plains is Texas and Oklahoma.

[b] Less than .01 lb per acre.

[c] Average for U.S. was 0.41 in 1971 and 0.38 in 1976.

cotton. Texas and Oklahoma harvested the largest acreage of cotton in 1976, with 5.3 million acres, compared to 3.3., 0.9 and 0.5 million acres in the Delta, Southeast, and Appalachia. Yet, unlike other Sunbelt states, the Southern Plains states applied the least amount of insecticide to cotton.

Southern Plains farmers have utilized a shorter season variety of cotton that is ready for harvest before insect problems become severe. The more arid climate in the region allows the farmer to avoid both the economic losses from insect damage and heavy spraying. A major drop in insecticide use in the South between 1964 and 1976 resulted from the adoption of new plant varieties and improved insect management practices, primarily by Texan cotton farmers and also by tobacco farmers in the Appalachian and Southeastern states (Crosson and Brubaker, 1981).

(b) Herbicides

Herbicide use increased over 400 percent in the U.S. from 1964 to 1976. The South's share remained constant at around 26 percent from 1964 to 1976. As shown in Table 9-8, total application in the South increased from about 19 million pounds to 98 million pounds during this period. This large increase was caused by increasing applications to corn, soybeans, sorghum, and wheat. Although acreage planted to these major field crops also increased in these years, the growth in herbicide applications far outpaced the growth in acreage planted. Considering pounds of herbicide used per acre, the South increased from 0.71 pounds per acre in 1971 to 1.08 in 1976, which was similar to the increase in the nation--from 0.65 to 1.07 (Table 9-6).

As shown in Table 9-9, the Delta states are first in the total amount of herbicides applied (34 million pounds), with the Appalachian states a close second (31 million pounds). The Southern Plains applied the least with 12 million pounds, even though it has the largest acreage planted to major field crops, hay, and pasture. The declines in usage on cotton, rice, and pasture and range in Texas and Oklahoma were offset by a huge increase (over 1,000 percent) in herbicide used on corn; otherwise total herbicide use by the two states might have shown a decline.

In the other three regions a substantial increase occurred in the amount of herbicides applied to soybeans. The Southeast, for example, applied less than half a pound per acre in 1971, but 1.7 pounds per acre by 1976.

In the Appalachian and Delta regions large increases per acre also occurred. All regions but the Delta showed large increases in the pounds of herbicide per acre applied to corn; in Appalachian the increase was from 1.31 to 3.53 pounds per acre.

TABLE 9-8: HERBICIDES USED ON MAJOR CROPS IN THE SOUTH[a] AND THE U.S.
(thousands of pounds)

Crop	Herbicides					
	South			U.S.		
	1964	1971	1976	1964	1971	1976
Corn	2,653	8,872	29,263	25,476	101,060	207,061
Cotton	4,515	17,685	16,112	4,628	27,610	18,312
Wheat[b]	64	177	1,122	9,178	11,622	21,879
Sorghum[b]	461	4,208	6,072	1,966	11,538	15,719
Soybeans	612	13,385	29,834	4,208	36,519	81,063
Tobacco[b]	3,060	a	1,132	11,206	a	1,209
Peanuts[b]		4,371	3,357		4,374	3,366
Rice[b]	4,380	7,096	8,452	9,119	7,985	8,507
Other grains[b]		37	221		5,377	5,476
Alfalfa, hay, and forage[b]	2,709	170	358	4,687	627	1,642
Pasture and range[b]		4,799	2,254		8,336	9,644
Totals	18,454	60,800	98,177	70,468	207,048	373,878
Percent of U.S. Total	26	29	26			

Sources: Data compiled from Eichers *et al.*, 1968 and 1978; and Andrilenas, 1974.

[a] Herbicide used on tobacco not available for 1971.

[b] 1964 data are aggregated for these crops, therefore comparable totals for these crops are given in parentheses.

TABLE 9-9: HERBICIDE APPLICATION RATES TO SELECTED MAJOR CROPS, BY REGION (pounds per acre)

Crop	Appalachian 1971	 1976	Southeast 1971	 1976	Delta 1971	 1976	Southern Plains 1971	 1976
Corn	1.31	3.53	.61	1.80	1.07	.96	.16	.94
Cotton	1.60	1.47	2.18	1.11	3.17	3.46	.69	.52
Wheat	.01	.06	.03	(a)	(a)	.05	.02	.07
Soybeans	.87	1.77	.47	1.71	1.03	1.55	.35	.02
Tobacco								
Peanuts	5.24	3.67	3.31	2.53	.50	(a)	.62	.66
Other grain	(a)	.11	(a)	.01	(a)	(a)	(a)	.04
Average All Major Field Crops[b]	.73	1.68	.80	1.32	1.47	1.81	.32	.33
Total Pounds[c] Used (thousands of pounds)	12,030	30,773	9,237	17,729	23,942	33,837	10,792	12,452

Sources: Data calculated from Andrilenas, 1974 and 1975; and Eichers et al., 1978.

[a] Less than 0.01 lb per acre.

[b] Average for U.S. was 0.65 in 1971 and 1.07 in 1976.

[c] Does not include the amounts applied to pasture and range.

(c) Summary of Pesticides

Although many changes have occurred in the use of pesticides in the past 15 years, some major patterns include the following:

- Organophospates and carbamates have replaced the more persistent organochlorines (DDT); this is a significant environmental benefit. Cotton has required large applications of insecticides, and the South received 93 percent of cotton insecticides in 1976;
- The South has shown a consistant reduction in insecticide use from 1971 to 1976. However, Delta and Southeastern states remain heavy users--50 percent of insecticide use in the U.S. The Southern Plains applied the least insecticide to cotton, accounting for a major reduction in use;
- A dramatic increase in herbicide applications has occurred. This has been most significant in the Delta region; and
- Very large increases in herbicide application to corn have offset reductions in herbicide use to many crops in the Southern Plains states.

These changes indicate that projecting trends in pesticides applications is likely to be difficult. Application rates in the South have varied around changing crop patterns, new insecticide types, new crop varieties and new pest management strategies.

3. Irrigation

In the Sunbelt, irrigation is primarily important to Florida, the Delta region, and the panhandle areas of Texas and Oklahoma. In Texas and Oklahoma, irrigation made possible the development of a large concentrated network of beef cattle feedlots. Irrigated land in the High Plains of Texas, New Mexico, and Oklahoma produces much of the corn, sorghum, and alfalfa feed to support the beef industry located there. Nearly all of the water used for irrigation purposes in this area is drawn from ground water. Problems associated with the drawdown of the Ogallala aquifer are discussed in Chapter 13 (Water Availability).

Table 9-10 shows irrigated land in the Sunbelt in 1974 and 1978. Nearly 80 percent of the irrigated land in the Sunbelt is in Region 6--of this, by far the largest percentage is in Texas. In Region 4, only Florida is a large irrigator. Florida and New Mexico irrigate half their cropland, while Texas and Arkansas each irrigate over 20 percent of their cropland. Importantly, pasture and other farmland is also irrigated. In Florida major field

TABLE 9-10: IRRIGATED LAND IN THE SUNBELT[a] (thousands of acres)

State	1974	1978
Region 4		
Alabama	14	59
Florida	1,559	1,991
Georgia	112	464
Kentucky	11	15
Mississippi	162	310
North Carolina	51	93
South Carolina	10	33
Tennessee	10	14
Total	1,929	2,999
Region 6		
Arkansas	949	1,686
Louisiana	702	682
New Mexico	867	904
Oklahoma	515	602
Texas	6,594	7,018
Total	9,627	10,892
Sunbelt Total	11,556	13,871
U.S. Total	41,243	50,838

Source: Compiled from U.S., Dept. of Commerce, Bur. of Census, 1981.

[a] All land irrigated for agricultural purposes. These data are from the U.S., Department of Commerce, Census of Agriculture, whose estimates of irrigated land are lower than those in the National Resource Inventory (USDA, SCS, 1978).

crops comprise only two-thirds of the state's total irrigated lands, with the other third composed of pasture, orchards, and vegetables. New Mexico, Oklahoma, and Texas also irrigate substantial areas of pasture.

The southeastern states have increased their irrigated cropland in recent years largely as a response to several years of drought that hit Georgia and Florida especially hard. In the 1980 drought, soybean yield fell by half. Although Region 6 and Region 4 added similar actual acreages (over 1 million) to their irrigated lands, this represented a percentage increase of 55 percent in Region 4 but only a 13 percent increase in Region 6.

With four consecutive years of drought (1977-1980) farmers in southwest Georgia are drilling irrigation wells faster than anywhere in the country (Gibson, 1981). By 1980 Georgia irrigated nearly one million acres of farmland. Many states of the Southeast are expected to expand their use of irrigation to help control the uncertainties of farming. However, since agriculture is the largest user of water, particularly in the western part of the Sunbelt, it is the sector most affected by water scarcity. Such effects currently are being experienced in the High Plains of Texas where some farmers have already switched back from irrigated feed grains to dryland production (see Chapter 13).

4. Farm Exports

The United States is the world's leading exporter of agricultural products. Wheat, feed grains, and soybeans account for about 60 percent of the total 32 billion dollars of farm exports (USDA, 1980). Farm exports are an important factor in the nation's balance of payments. In 1979 the aggregate net contribution of agricultural exports to the U.S. balance of payments was over 16 billion dollars, nearly one-fifth of the nation's total exports (USDA, 1980).

The proximity to ports and navigable rivers has given the South an advantage in the export market and has had a major effect on the Mississippi Delta area in particular. The Delta states have shifted much of their rich alluvial soils from bottomland forest to corn and soybeans. The result is a concentration of very large cash grain farms in the Delta as well as in the Great Plains (Batie and Healy, 1980). The southward shift in feed grain production and the building of storage and other major port facilities between Baton Rouge and the Gulf probably will continue to focus foreign demand on the lower Mississippi Valley.

9.2.2 Future Developments

A. Trends in Land Use

Cropland in the South has shifted in and out of production according to market demands and agricultural practices. Between 1967 and 1975, for instance, 19.6 million acres shifted from cropland to pasture in the South and 10 million acres shifted from pasture to crops (Table 9-11). A study of land conversion showed that quality cropland once converted to pasture and range apparently has only a 50 percent chance for return to cropland because of the economics of conversion, erosion problems, and small tract size (as cited in Conner, Travis, and Trudeau, 1980).

More than half the agricultural land converted to other uses in the U.S. between 1967 and 1977 was in the South. During this time the Sunbelt lost 13.6 million acres of agricultural land to urban, transportation, and water projects (see Chapter 12). About 30 percent of this loss was from forest, 20 percent from cropland, 20 percent from pasture and range, and the remaining 30 percent from conversion to idle land or rural residences.

However, the past loss in cropland may have been related to "overproduction" of crops. In the 1950's and 1960's federal policies idled cropland in an effort to avoid the overproduction of crops and low farm prices. By 1981, however, this trend was reversed and the South was planting nearly as much cropland as was planted in 1949 (Frey, 1979; USDA, Statistical Reporting Service, Crop Reporting Board, 1981). But this new cropland is not the old idled cropland. The Delta states (Arkansas, Louisiana, and Mississippi) are now planting one-third more cropland than in 1949, while the other three regions of the South are cropping far less than in 1949.

Despite these historic decreases and recent increases, most of the potential new U.S. cropland is in the Sunbelt. Nearly half the total 125 million acres of U.S. land with cropland conversion potential are located in the Sunbelt (Table 9-12). Twelve of the 24 million acres of convertible prime farmland in the U.S. can be found in the South (Lee, 1978).

How much land actually shifts to the production of crops depends on factors such as export demand, the cost of conversion, the short-term rewards, state land protection policies, anticipated gains in productivity, and priorities of individual farmers and landowners. It appears that land may continue to be brought into cultivation as long as the demand remains strong and the cost/price ratio is favorable. In general, growth opportunities for agriculture in the South on a regionwide basis do not appear to be limited by land availability over the near term.

TABLE 9-11: LAND USE SHIFTS, 1967 TO 1975
(millions of acres)

	From Cropland to					To Cropland from				
Region	Pasture and Range	Forest	Urban and Water	Other[a]	Total	Pasture and Range	Forest	Other[a]	Total	Net Shift in Crop-land
Appalachian	5.7	1.9	0.8	0.8	9.2	3.2	1.9	0.8	5.9	- 3.3
Southeast	3.2	1.8	0.7	1.6	7.3	1.9	2.2	0.4	4.5	- 2.8
Delta	1.7	0.5	0.4	0.2	2.8	1.6	2.1	0.2	3.9	+ 1.1
Southern Plains	9.0	0.2	0.8	0.8	10.8	3.3	0.3	0.2	3.8	- 7.0
Total South	19.6	4.4	2.7	3.4	30.1	10.0	6.5	1.6	18.1	-12.0
Total U.S.	52.9	8.3	13.0	5.4	79.6	31.9	11.0	5.8	48.7	-30.9

Source: Data complied from Schenarts, 1981.

[a] Other is idle land or rural residences, etc.

TABLE 9-12: CURRENT CROPLAND AND NONFEDERAL LAND IN OTHER USES WITH CROPLAND CONVERSION POTENTIAL, 1977 (millions of acres)

State	Current Crop-land	Potential Conversion to Cropland[a] Pasture and Rangeland	Forest	Other[b]	Total	Potential Future Cropland (current plus potential)
Region 4						
Alabama	4.5	2.4	1.8	(c)	4.1	8.6
Florida	3.2	2.8	0.8	(c)	3.0	6.2
Georgia	6.5	1.9	3.9	(c)	5.8	12.3
Kentucky	5.4	2.4	0.6	(c)	3.1	8.5
Mississippi	7.3	1.8	1.9	(c)	3.8	11.1
North Carolina	6.2	1.0	3.9	0.1	5.0	11.2
South Carolina	3.3	0.7	1.5	(c)	2.2	5.5
Tennessee	4.9	2.4	1.3	0.1	3.7	8.6
Total	41.4[d]	15.3	15.7	0.3	30.7	72.1
Region 6						
Arkansas	8.0	2.0	1.2	0.1	3.3	11.3
Louisiana	5.9	1.3	1.6	(c)	2.9	8.8
New Mexico	2.3	1.3	(c)	(c)	1.3	3.6
Oklahoma	11.8	5.5	0.3	(c)	5.8	17.6
Texas	30.4	13.6	0.5	0.1	14.2	44.6
Total	58.4	23.7	3.5	0.3	27.5	85.9
Sunbelt						
Total	99.8	39.0	19.2	0.6	58.2	158.0
U.S. Total	413.0	90.4	30.9	3.4	124.7	537.7

Source: Data compiled from USDA, SCS, 1978.

[a] High and medium potentials for conversion to cropland were based on commodity prices, production costs, and development costs in 1976. The data in the table may well change in the future as the relative cost of conversion declines compared to commodity prices.

[b] Other nonfarm includes land used for greenbelts, unwooded parks, and other nonfarm use.

[c] Less than 100,000 acres.

[d] Columns may not add to the totals because of rounding.

B. Trends in Agricultural Earnings

Agricultural production is expected to continue its growth during the next 30 years barring any major reduction in domestic or export demand, according to the Department of Commerce (U.S., Dept. of Commerce, BEA, 1980). Expected income of the agricultural industry is one measure of the growth and changing importance of agricultural production to a state's economy. Within the Sunbelt the greatest relative increases in agricultural earnings by the year 2010 are expected to occur in Kentucky, Oklahoma, Louisiana, New Mexico, Florida, Texas, and Georgia, with lower percentage increases in Alabama, Mississippi, South Carolina, Arkansas, and Tennessee (Table 9-13). Overall U.S. agricultural earnings are expected to increase by 59 percent while the Sunbelt increases its earnings by 57 percent.

Little change is expected in the crops grown and the location of production of major crops, except in the Delta states where an expansion of rice production is expected in the future (Schertz et al., 1979, p. 331). Soybeans are expected to remain the leading crop, particularly in the Delta, and corn may remain an important crop in most areas of the Southeast and Appalachian regions. Peanut and tobacco production is expected to continue in the present localized areas. Wheat should remain the most important crop in the Southern Plains, while cotton is expected to decline in importance.

As shown in Table 9-14, many factors will determine future crop production. If changes occur in the availability or cost of fertilizer, seed, or water, crop production will fluctuate. If pesticide use is restricted, conversion of crop land to no-till agriculture will be hindered, resulting in greater soil erosion and higher input costs than those currently anticipated. In addition, improvements in pest control and further developments in production technologies may influence the competitive advantage of some crops and thus change the production mix in specific areas.

C. Trends in Farming Practices

The use of fertilizers and pesticides is expected to continue to increase. As indicated in Figure 9-1, nationally, the use of nitrogen fertilizer and pesticides has been projected to double

TABLE 9-13: PROJECTED GROWTH IN AGRICULTURAL INDUSTRY EARNINGS[a] (millions of 1972 dollars)

State	1978	1990	2000	2010	Percent Change 1978-2010
Region 4					
Alabama	411	386	440	510	24
Florida	912	1,107	1,345	1,629	79
Georgia	521	634	741	875	68
Kentucky	437	605	732	885	102
Mississippi	416	428	455	503	20
North Carolina	1,069	1,107	1,317	1,572	47
South Carolina	213	221	231	253	18
Tennessee	282	276	278	296	5
Total	4,260	4,763	5,539	6,522	53
Region 6					
Arkansas	665	670	733	828	24
Louisiana	242	315	381	460	90
New Mexico	160	200	239	288	80
Oklahoma	253	407	449	510	102
Texas	880	1,211	1,340	1,524	73
Total	2,200	2,802	3,142	3,609	64
Sunbelt Total	6,459	7,564	8,681	10,131	57
U.S. Total	22,125	25,752	29,921	35,205	59

Source: Data calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] Specified by the Bureau of Economic Analysis as earnings of "agriculture (farming)."

TABLE 9-14: MAJOR FACTORS AFFECTING CROP PRODUCTION

Crop Production Area	Factor
External Needs (financial, material, or technical)	Uncertain resource availability
	Questionable resource/use efficiencies
	Potentially inappropriate land use
	Potentially declining water supplies
	Unassured energy availability
	Inadequate capital financing
Management-Related	
Technology use restraints	Restricted pesticide use
	Potential fertilizer use constraints
Education	Unassured implementation of new management systems
Environmental plans	Impending requirements for state and local environmental plans
Products or Outputs	
Economics/markets	Market instabilities
	Irregular export markets
Residuals	Composite environmental effects
General Factors	
Institutional	Insufficient government coordination
	Inadequate agricultural representation
	Insufficient basic science research
Climate/weather	Uncontrollable climate/weather

Source: Adapted from U.S., EPA, 1979.

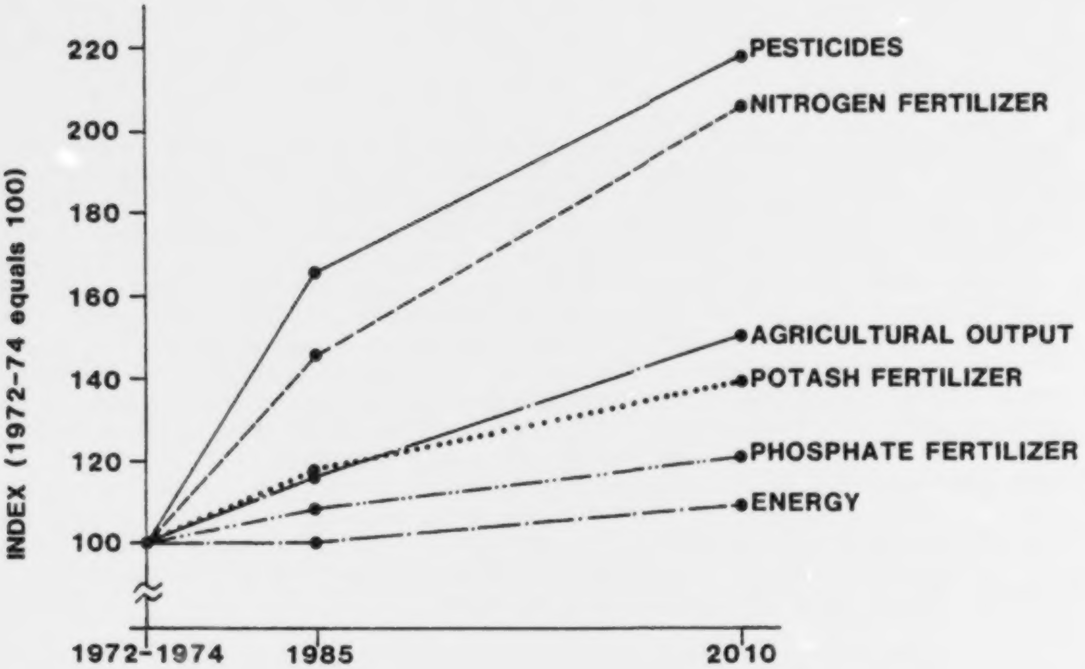

Figure 9-1: Energy and Fertilizer Requirements to Achieve Moderate Growth Projections

Source: U.S., EPA, 1979, p. 27.

by the year 2010 (U.S., EPA, 1979).[1] Irrigation may increase in the Delta and Southeast regions, but decline in some portions of the Southern Plains (Wittwer, 1980). If new conservation practices and new agricultural technologies are implemented in the future, these possible trends would be modified. This section discusses future irrigation, pesticide use, conservation tillage, best management practices, integrated pest management, and new technologies.

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[1] Projections were based on a recent EPA sponsored study conducted by Development Planning Associates. The moderate growth scenario assumed growth of U.S. population to 281 million by 2010 and that material, land, and technical requirements were not major limitations, and that demand would expand in a pattern similar to the recent past. For a more detailed description see U.S., EPA, 1979. The projection is used here to indicate a potential pattern of development, rather than a forecast of the future, and should be interpreted cautiously.

1. Irrigation

The use of irrigation in the future will vary from state to state. In some areas depleted water tables will force a reduction in ground water use. In the panhandles of Texas and Oklahoma and a few eastern counties of New Mexico, irrigation peaked in 1965. Declining ground water tables in the Ogallala aquifer already have forced a reduction in use and rising energy prices may further reduce pumping and withdrawals. In Texas, near the southern end of the aquifer, farmers have already begun to change from irrigated feed grains back to dry land farming. A recent USDA study concluded that irrigation in 32 counties in the Texas plains would end by about 1995; the major land use consequence would be a 70 percent decrease in grain sorghum output and a return to wheat as the main dry farming crop (Young and Coomer, 1980). The decline of irrigation will result in drier soils and likely worsen wind erosion in the area. At the same time, however, the change in crop species should lead to a decrease in the amount of herbicides used in the area.

In contrast, in the eastern portion of the Sunbelt irrigation may be the next major means of increasing crop productivity (Wittwer, 1980). This is already taking place in Georgia and South Carolina.

Increasing the efficiency of water use by crops is likely in the future. Crops vary considerably in efficiency of water use. Sorghum, for example, produces 1.72 kilogram (kg) of grain per millimeter of water compared to 1.23 kg for wheat, 0.65 kg for peanuts, and 0.24 kg for cotton (Wittwer, 1980). However, more likely improvements in water use will probably come from an increase in irrigation efficiency. Such activities as lining irrigation canals that channel water to farms, installing flow monitoring and regulating mechanisms that control the rate, amount and timing of application, land grading to level field surfaces, and the use of drip or trickle irrigation wherever economical will increase the efficient use of water in the future (S&PP, 1982, Ch. 4).

2. Pesticides

The growth rate in the use of pesticides depends to a major extent on crop production decisions made by individual farmers, regulation policies, and market factors. For example, cotton growers in the Delta may continue converting their fields to soybeans in response to market demand thereby decreasing the pounds of insecticide applied to each acre. On the other hand, other farmers may choose to practice conservation measures such as low-tillage that may increase the amount of herbicides and insecticides that must be used.

Because insecticides are predominantly applied to the cotton crop (except in the Southern Plains), growth in insecticide use in the Sunbelt depends to a large extent on the levels of production and conservation measures adopted by cotton growers. While the Delta and Appalachian regions had fewer acres of cotton in 1981 than in 1976, the Southeast region quadrupled its cotton acreage. In 1976 the Southeast had the highest rate of insecticide application to cotton (22 pounds per acre). The trend of increased cotton acreage since 1976 probably has been accompanied by an increase in insecticide use.

3. Conservation Tillage

Reduced or conservation tillage involves substituting chemical herbicides for mechanical cultivation to control weeds. This can vary between no-till in which a spray-plant-harvest system is used and low-till which includes some cultivation. Conservation tillage reduces erosion of croplands by 50 to 90 percent, reduces soil compaction, and increases moisture content from the mulching effect. On the other hand, environmental impacts may result from increased herbicide use and lower soil temperature in the spring that may delay early germination.

Low-tillage has been most successfully used on corn, soybeans, sorghum, and other grains. It is not successful in areas with poorly drained soils or in regions such as central and eastern Texas where persistent perennial weeds such as Johnson grass and Burmuda grass are common. Such weeds are nearly impossible to control successfully with herbicides.

The use of reduced tillage in the U.S. has spread from 14 percent of all harvested cropland in 1973 to 23 percent in 1979 (Crosson and Brubaker, 1981). In the South, the Appalachian and Southeast regions make greater use of the method than do the Delta or Southern Plains (Table 9-15). If present trends continue, 50 percent of U.S. cropland may be farmed using no-till or low-till methods by 2010 (Conner, Travis, and Trudeau, 1980).

4. Management Practices

Best management practices refers to the application of currently known farming practices that minimize runoff, conserve soil, and foster the more efficient use of chemicals and water. The practices have been developed by states through their area-wide waste water management programs in close conjunction with Soil Conservation Service Districts. These practices include

TABLE 9-15: LOW-TILL FARMING IN THE SOUTH BY REGION
(million of acres)

Region	1978		1979	
	Area	% Cropland Harvested	Area	% Cropland Harvested
Appalachian	5.42	29.8	5.83	30.7
Southeast	4.55	31.4	5.09	33.5
Delta	1.26	6.7	1.36	7.0
Southern Plains	2.24	7.5	1.98	6.1
U.S.	74.67	22.6	79.11	23.1

Sources: Crosson and Brubaker, 1981, p. 84.

strip cropping which combines grass or fallow areas with cultivated crops; terracing or constructing grass waterways to utilize surface runoff; growing winter cover crops to protect soil; and timing farm operations to minimize exposure of soil. Expanded use of best management practices may reduce soil loss and chemical pollution in the southern region.

Integrated pest management (IPM) programs are sponsored primarily by the USDA to reduce losses from pests while also reducing dependence on environmentally harmful chemicals. IPM uses a combination of biological, chemical, and physical techniques to control pests that threaten crops. With IPM, field monitoring is used to determine if, when, and where chemicals are needed. Biological controls include the use of natural enemies, resistant plants, and sterile insects, while other controls involve crop rotation, and the timing of planting and harvesting. The use of insect hormones is an additional biological method that is expected to be used more extensively by 2010 (U.S., EPA, 1978).

If IPM were implemented by large numbers of farmers, future pesticide use could be decreased significantly. For example, if IPM were used on cotton in the Southeast and Delta, insecticide use might be reduced by 35 to 50 percent (Bottrell, 1979). However, since herbicide use is increased in reduced tillage, herbicide use may not drop even with IPM.

5. Future Technologies

Emerging technological breakthroughs could enhance future agricultural productivity. Genetic engineering may produce plants that are tolerant of salt water, acid soils, air pollution, or harsh climate and that can resist both drought and insect attack. In addition, crops may be developed that are able to self-degrade broad spectrum herbicides. At the present time these herbicides kill crops along with weed pests. Genetic research may also further improve the nutritional value of cereal grains. One major breakthrough would be increasing the photosynthetic efficiency rate, which in most plants is less than one percent.[1] With this development, plant growth could be regulated, plant anatomy could be improved, and crop yields could be maximized far beyond their current limits (Wittwer, 1980).

Less than 50 percent of the nitrogen and less than 35 percent of the phosphorus and potassium that are applied are actually utilized by crops. The processes of nitrification[2] and denitrification[3] cause millions of tons of fertilizer to be lost to the environment each year in the South. Nitrification inhibitors are already available; widespread use of inhibitors could significantly reduce fertilizer use. Another technology that may reduce the need for fertilizer applications is to augment biological nitrogen fixation (Wittwer, 1980). Some rice paddies, for example, already use microorganisms to provide the nitrogen requirement.

Research in animal production to control infectious diseases, develop genetically superior animals (e.g., who can survive on low-quality diets), and encourage twinning in beef and dairy cattle may impact the system of livestock production. Also important are genetic improvements in producing higher yielding and more nutritive forage.

The adoption time for new agricultural technologies has apparently averaged 13 years and may take up to 35 years, so that even if some of these developments were acheived they may not have a widespread effect on farming practices until after the mid-1990's or later (Wittwer, 1980). Some experts believe the level of agricultural research support from the public sector has not been large enough recently to expect anything more than modest productivity improvements (Ruttan, 1980).

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[1] Some plant efficiencies are as high as 3 percent. Although improvements in the efficiency of some crops have been made, a major breakthough such as doubling efficiency, is apparently difficult to achieve.

[2] Nitrification is the process whereby ammonia is oxidized by soil bacteria to form nitrates which may facilitate growth of some plants, but also allows nutrients to be leached into streams and lakes.

[3] Denitrification reduces nitrate to gaseous nitrogen which is then lost to the atmosphere.

D. Future Export Demand

Crop exports have caused a realignment in crop production and expansion of cropland used in the South, particularly in the Delta and Southern Plains states. Future export demands have been based on projections of world population growth, agricultural growth in developing nations, consumptive levels in importing nations, and import and export policies. Table 9-16 reports the production and export level of four crops for the years 1977 to 1979; a projection by the USDA for 1990 levels; and one for 2010 made by Resources For the Future (RFF). The USDA projections assume U.S population will grow by 3 percent annually, that export growth will be more moderate than in the 1970's, and that real Gross National Product (GNP) will grow 3 percent per year. The RFF projection additionally assumes the U.S. will maintain a constant share of the export market and that no major changes will be made in import policies by the importing countries. These projections indicate that the three major export crops are expected to increase in production and exports. The rate of growth in feedgrain exports to the year 2010 is the largest with a 177 percent increase. If these projected demands are to be met, agricultural production will have to increase by three-fourths.

9.2.3 Environmental and Health Concerns

The runoff of rains or irrigation waters from agricultural lands is the main contributor to agricultural pollution. The runoff transports soil which becomes a pollutant--sediment--that causes turbidity and deposits that can ruin fish spawning areas and accumulate in rivers and lakes. In addition, this sediment transports nutrients (from animal wastes and commercial fertilizers), salts, and pesticides as well as other suspended materials such as heavy metals that pollute water systems. Animal wastes are a major source of surface water contamination by BOD and nutrients. This section discusses the most important environmental issues associated with agricultural production in the Sunbelt.

A. Soil Erosion

Soil erosion refers to the loss of soil by wind, rain, or moving water. It is a serious environmental problem because it threatens long-term productivity. If soil is blown or washed away at a faster rate than new soil is naturally generated,

TABLE 9-16: PRODUCTION AND EXPORT OF WHEAT, SOYBEANS, FEEDGRAINS, AND COTTON
(millions of metric tons)

Crop	Average 1977/79	Projection 1990	Projection 2010
Wheat			
Production	54	77	98
Exports	34	50	70
Soybeans[a]			
Production	54	72	120
Exports	28	34	76
Feedgrains[b]			
Production	219	282	354
Exports	60	97	167
Cotton			
Production	3	3	NA
Exports	1	1	NA

NA = Not available.

Source: Data compiled from Crosson and Brubaker, 1981.

[a] 1990 projection is for beans only. The other figures, include soybean meal and oil converted to the bean equivalent.

[b] Corn and sorghum for grain, plus oats and barley.

topsoil depth is reduced and subsoil becomes part of the plowed soil profile, reducing the soil's organic matter, its nutrients, aeration and water holding capacity, and other structural characteristics that are beneficial to plant growth (Crosson and Brubaker, 1981). Furthermore, displaced soil and attendant agricultural chemicals then become pollutants of adjacent lands and waterways (see Chapter 14).

Erosion is an insidious problem whose long-term cost is generally given less weight than more immediate production problems, particularly on rental farmland. In the short term, soil productivity losses can be overcome by larger applications of fertilizer, but the true cost of allowing soils to erode may ultimately be paid in yield reductions and production cost increases in the near future and total destruction of some lands in the long term.

As discussed in more detail in Chapter 12, eight of the 13 Sunbelt states have waterborne soil erosion rates greater than the national average of 4.77 tons lost per acre per year.[1] With theexpected expansion of cropland, the current high erosion rates in the Sunbelt may create serious erosion and sedimentation problems. Of course, using average erosion rates for a region or a state obscures the fact that some lands are losing virtually no soil at all while others, such as western Tennessee or the High Plains of Texas, are experiencing extremely high soil loss.

Some farming practices minimize erosion. These include some of the best management practices, such as intercropping, terracing, contour cropping, and winter cover cropping. Spring plowing, which minimizes the length of time soil is left bare, also reduces erosion. Probably the most significant practice in reducing erosion is conservation tillage. As previously discussed, the use of some of these conservation practices has been projected to increase in the future. In the South, for example, 80 to 90 percent of all cropland may be planted with winter crops by 2010 (U.S., EPA, 1978).

The potential effects of best management practices on productivity and erosion control could be large. However, changes in erosion control practices do not occur as rapidly or extensively as crop planting in response to crop prices. In fact, the USDA Soil Conservation Service reports that throughout the country farmers are not managing highly erodible soils as well as farmers did a generation ago (Rosenberg, Knutsen, and Harmon, 1980). Much of the accumulated evidence suggests that adopting erosion control methods is not cost-effective for the farmer. A team studying eroding land in southern Iowa calculated "projected near-term costs of erosion in terms of additional energy use, additional fertilizer use, and reduction in yield," and found that the costs of reducing erosion to a rate approaching that of actual natural soil development was about three times the economic benefits of doing so (Rosenberg, Knutsen, and Harmon, 1980). Thus, when a farmer extends his cultivation onto land previously considered marginal or too erodible for cropping, he is not likely to expend the full effort needed to maintain that topsoil resource.

How widespread or effective soil conservation practices will be in the future is unknown. Most were shown to be effective in protecting the soil base 50 years ago, yet most farmers still do not fully employ them. In fact, no more than 25 percent of U.S.

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[1] As discussed in Chapter 12, average cropland water erosion in the Sunbelt states varies from 2 to 14 tons per acre per year.

farmlands are currently operated under accepted conservation practices (Wittwer, 1980).

B. Nutrients

In heavily farmed areas, pollution to surface water ranks next to large municipal discharges in terms of nutrients additions (U.S., EPA, 1980). This form of pollution together with pesticides enters streams via sediment that erodes from topsoil. Together, these substances act to degrade fish and marine life habitat (see Chapter 12). They cause such adverse effects as changes in water temperature, increased oxygen demand and decreased light penetration (see Chapter 14).

Both commercial fertilizer and animal wastes are sources of nutrients. The effects of manure disposal from feedlots in the Sunbelt is largely concentrated in the major livestock producing areas. Nitrogen and potassium from commercial fertilizer can reach surface waters by runoff; nitrogen also percolates through the soil to ground water supplies.

The projected increases in fertilizer use are high for most of the Sunbelt. Conservation measures may affect the amount actually delivered to surface water. The concentrations of nitrogen, ammonia, and phosphorus are actually higher in runoff from low-tilled fields than from conventionally-tilled fields (Crosson and Brubaker, 1981). The amount of runoff is usually smaller from low-till fields, so more water stays on the field, which may leach to ground water. Thus, the threat of nitrate pollution may actually be greater on no-tilled cropland.

Problems are likely to be significant in the Southeast where increases in irrigation, crop production, and fertilizer use are expected in Georgia and northwest Florida. If crop residues are used for ethanol production (see Chapter 6) in the future, sedimentation and water pollution will probably increase due to compensating heavier applications of nutrients and consequent higher rates of erosion.

C. Pesticides

Pesticide residues are found in soil, water, and air as well as in human food (see Chapter 12). They can enter the environment during application, by runoff, or percolation. Approximately 5 percent of the pesticides applied eventually are transported off the land.

As indicated earlier, herbicide applications have increased dramatically. Low-till agriculture increases the use of herbicides because some of the herbicide gets tied up in the residue on the soil and the additional soil moisture enhances weed germination and growth. However, with reduced erosion and runoff, fewer herbicide residues may find their way into the water systems (Table 9-17). Chemicals applied stay on the soil longer and expose wildlife to crop residues.

Neither the nation nor the South has historic experience with the large applications of herbicides currently used. In the case of many insecticides, less may be used in the future, at least in some regions like the Delta, so fewer environmental problems may result. For example, cotton production is shifting from the Delta to Texas where the need for insecticide is less. Currently, the Delta and Southeast apply the most insecticide (69 percent of it to cotton), so the environmental impacts are geographically concentrated. More extensive use of plant varieties with insect resistance may lower pesticide usage by the 1990's. The shift away from organochlorines probably will continue. Whether this will mean increased environmental problems from the more toxic substitutes is unknown (see Chapter 12).

D. Irrigation

Salinity is one of the most pervasive environmental problems associated with irrigation. Salts can accumulate on soils and increase in surface waters as they receive the irrigation runoff. In the Sunbelt irrigation is associated with salt accumulations in Texas, New Mexico, and Oklahoma (see Chapter 14).

Reduction of streamflow and mining of ground water can also be significant problems. Ground water depletion has occurred in many states, but is of major significance in the Southern Plains (see Chapter 13).

Irrigation may also intensify erosion problems. When not used on level cropland, flood and furrow systems can increase erosion; if used on sandy soil and hilly terrain the central pivot irrigation systems may increase erosion; and the large sprinkler systems may cut wheel tracks that can lead to gully erosion (Crosson and Brubaker, 1981).

But irrigation can have positive effects as well. In arid regions, it sustains a better vegetative cover that reduces erosion and runoff, it enhances productivity by reducing crop failure and it often encourages land leveling which reduces erosion. The use of more efficient irrigation systems could reduce withdrawals as would the reuse of runoff. Also, local wastewaters might be treated for return to surface waters. But such measures may be unlikely on a widespread basis unless increased water costs make them more economically acceptable.

TABLE 9-17: WATER, SOIL, AND HERBICIDE LEAVING CONVENTIONAL AND NO-TILL CORN FIELDS

Tillage	Total Cyanazine Applied (lbs per acre)	Amounts Leaving Cropland: Water (inches)	Amounts Leaving Cropland: Soil (tons per acre)	Amounts Leaving Cropland: Cyanazine (lbs per acre)
Conventional Plowed	4.0	3.83	14.37	0.21
No-Till Cornstalk Residue	6.0	0.38	0.37	0.03
No-Till Crown Vetch	6.0	0.13	0.03	0.01

Source: Conner, Travis, and Trudeau, 1980.

E. Issues of Land Use

Competition for U.S. cropland exists within the agricultural sector and among agricultural and other sectors. There is concern that land available for cropland conversion is too rapidly being converted to irreversible nonagricultural uses, such as housing, highways, and reservoirs (USDA and CEQ, 1981). As discussed earlier in section 9.2.2, the South lost cropland from the early 1900's to the 1970's, with much of this land abandoned to forest. Over 13 million acres of forest and cropland were converted to other uses between 1967 and 1977 in the Sunbelt (see Chapter 12). The nation may depend more heavily on the South to provide new fertile cropland for export grains as well as ample forests for lumber products at the same time that increased population is creating pressures for housing, recreation areas, and other nonagricultural uses. Although the South contains most of the potential farmland, conflicts are likely to occur as competing land use demands intensify.

As discussed in Chapter 12, environmental effects of emerging land use demands in the South include loss of habitat for many wildlife species, the farming of additional acreages of marginal land with possible soil degradation, and decreases in flood protection. A shift toward farming additional marginal lands may result in higher erosion rates and heavier fertilizer use.

State level efforts may protect and preserve agricultural lands by offering tax incentives, or by zoning and districting. However, at present only 20 million acres of cropland in the U.S. are protected under comprehensive state or local programs (USDA and CEQ, 1981, p. 16). The National Agricultural Lands Study found that the South is doing less than other regions to protect agricultural lands.

9.3 FOREST LAND AND TIMBER PRODUCTS

The Sunbelt contains about 220 million acres of forest land (Frey, 1979). Except for Kentucky (48 percent), states in Region 4 are more than 50 percent forestland. Only Oklahoma, Texas, and New Mexico in Region 6 have less than 25 percent forestland, but even in parts of these states forestry is an important enterprise.

Much of the forest area is used for timber production, but large portions remain as unmanaged woodlots, providing benefits to wildlife and fish, recreational use, livestock grazing, and mineral production. In 1976 the South[1] produced 31 percent of the nation's softwood lumber, 37 percent of the softwood plywood, and 76 percent of the softwood pulpwood (Williston, 1979). It generally is expected that the timber harvest within the region will expand in the coming decades, as demand for products continues to expand and as Pacific Coast old growth forests are harvested and second growth may not yet be adequately available. This will add to current pressures on both terrestrial and aquatic ecosystems caused by forest management and harvest practices within large portions of the southern region.

The following pages discuss current activities and expected developments in the timber industry, and some of the associated environmental impacts. The forest industry harvests wood for production of pulp and paper, as well as boards and plywood. The former are discussed further in Chapter 10, but it should be remembered that growing the wood fiber used in the pulp and paper industry involves the same land use and ecological issues brought out in this discussion.

9.3.1 Current Status

In 1970 the U.S. used 39 billion board feet of lumber and 18 billion square feet of plywood, as well as large amounts of particle or insulation board, and forest products for pulp and paper. By 2020, consumption is expected to increase to 54 billion board feet of lumber and 46 billion square feet of plywood, with the forests of the Sunbelt supplying a greater percentage of the total national consumption in the future (USDA, Forest Service, 1977). New housing is the largest single consumer of lumber and plywood and future forestry activity will no doubt be affected by housing demand and technology.

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[1] The Sunbelt minus New Mexico and including Virginia.

Forestry provides large industry earnings in localized areas of the South. The values appear small when seen as percentages of total state industrial earnings (1 to 3 percent) but in 1978, the Texas, North Carolina, Alabama, and Georgia lumber products industries earned 313, 274, 243, and 237 million (1972) dollars respectively (U.S., Dept. of Commerce, BEA, 1980).

In 1970 the South had 201 million acres of commercial forest land, that is, forest land producing or capable of producing annually in excess of 20 cubic feet of wood per acre. This commercial timber land covers very large portions of Region 4, and of Arkansas and Louisiana (Figure 9-2), from 67 percent of the State of Georgia to 46 percent of Kentucky (USDA, Forest Service, 1977). Although Texas and Oklahoma have very low percentages of forest, they have some large acreages in commercial status.[1]

A. Forest Types

The study area contains a wide variety of hardwood and softwood forest types (see Chapter 12 for a description of forest types). The largest part of the area is in southern pine forest (61.9 million acres) and oak-hickory forest (59.4 million acres), according to the U.S. Forest Service (1980) (Table 9-18). The southern pine forest was the source of 25 percent of the total U.S. timber harvest but only 14 percent of the nation's commercial timber lands in 1970 (USDA, Forest Service, 1977). Loblolly pine comprises nearly half the inventory and is the keystone of the southern pine forest products industry (USDA, Forest Service, 1980). Except in Florida, where slash pine prevails, loblolly is the dominant pine species in each of the Atlantic and Gulf coastal states.

A mixed oak-pine forest is also important in the South, frequently in stands left after cutting of larger pine in pine-hardwood forests. Through hardwood removal, some of these oak-pine areas have been converted to pine timberlands. The oak-pine forest is not as productive as the pine ecosystems for timber, but provides valuable habitat for numerous wildlife species (USDA, Forest Service, 1980).

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[1] Commercial forest land refers not to ownership but to productivity, and within the region almost all forested acreage is in that category. Much of the following discussion refers to commercial forest land.

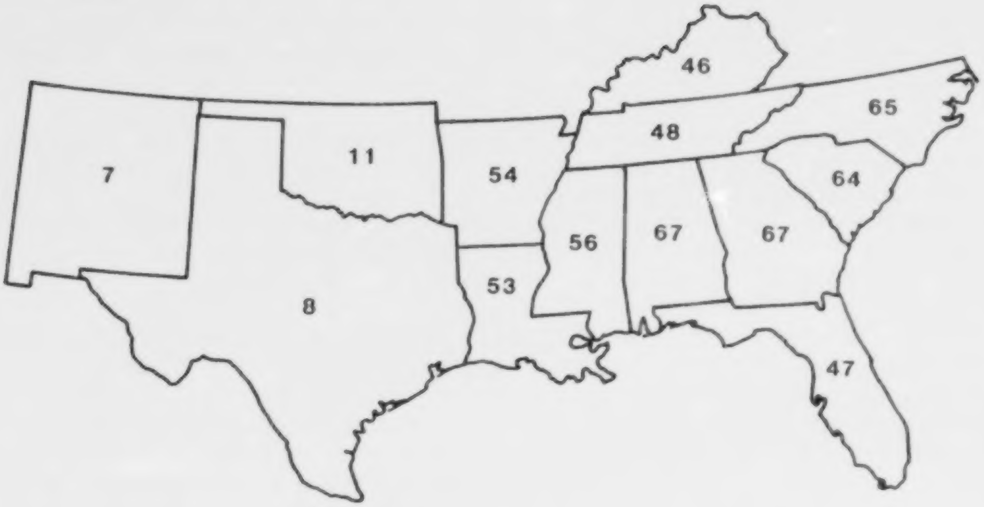

Figure 9-2: Commercial Timberland as a Percentage of Land Area

Source: USDA, Forest Service, 1977, p. 18.

The oak-hickory hardwood forests make up one-third of the total forest land area in the South. In some localities this forest type produces choice industrial hardwoods--examples are the bluffs that flank the eastern edge of the lower Mississippi Valley and the valleys of the southern Appalachians. This forest type occurs on millions of acres, especially on the Coastal Plain, that are regarded by industry as better for growing pine than hardwood (USDA, Forest Service, 1980).

Swamp and bottomland forests (oak-gum-cypress and elm-ash-cottonwood) have long been the mainstay of the southern hardwood forest products industry. In recent years, however, changing land-use patterns have reduced them. Extensive acreages of prime bottomland hardwoods have been cleared for agriculture on the alluvial soils of the Mississippi Valley.

New Mexico does not fit into the southern forest pattern, having relatively little forest area and none of the southeastern forest types; its timber land is mainly Douglas fir and ponderosa pine.

TABLE 9-18: FOREST LAND AREA BY ECOSYSTEM AND SECTION, REGION, AND STATE, 1977 (thousand acres)

	Ecosystem										
Region/State	All Eco systems	White-Red-Jack Pine	Fir-Spruce	Longleaf Slash	Loblolly-Shortleaf	Oak-Pine	Oak-Hickory	Oak-Gum Cypress	Elm-Ash-Cotton-wood	Maple-Beech-Birch	Non-stocked
Region 4											
Alabama	21,361			1,485	6,388	5,024	5,839	2,419	95		109
Florida	17,039			6,370	1,064	1,406	999	4,752	75		2,370
Georgia	25,256	30		5,310	6,928	4,121	4,738	2,914	554		658
Kentucky	12,160	38			955	1,068	7,634	101	949	1,367	46
Mississippi	16,715			1,051	4,271	3,473	4,284	3,258	221		154
North Carolina	20,043	147	14	532	6,100	2,495	7,440	2,179	424	220	488
South Carolina	12,249	8		1,049	4,335	2,070	2,387	1,732	276		389
Tennessee	13,160	99	16		1,299	1,641	9,252	547	150	120	32
Total	137,983	322	30	15,797	31,340	21,298	42,573	17,902	2,744	1,707	4,246
Region 6											
Arkansas	18,281				3,685	3,042	8,461	2,767	274		81
Louisiana	14,558			1,000	4,046	2,204	1,669	4,802	508		325
New Mexico[a]											
Oklahoma	8,513				860	698	2,207	846	124		169
Texas	23,279			259	4,540	2,576	4,455	1,942	210		165
Total	64,631			1,259	13,131	8,520	16,792	10,357	1,116		740
Sunbelt Total	202,614	322	30.	17,056	44,471	29,818	59,365	28,259	3,860	1,707	4,986

Source: USDA, Forest Service, 1980.

[a] New Mexico has different forest ecosystems types: total 18,059; douglas fir 1,279; ponderosa pine 4,231; fir spruce 741; other softwood 56; western hardwood 440; nonstocked 205; chaparral 427; pinyon juniper 10,679.

B. Forest Ownership

Almost 90 percent of the commercial forest resources of the Sunbelt are privately owned (Table 9-19) (USDA, Forest Service, 1977). Some privately owned forests are not managed but most national, state, county, and city forests are managed to provide a supply of harvestable timber. The vast majority of commercial timber lands is owned by farmers (34 percent) and miscellaneous private parties (39 percent) (USDA, Forest Service, 1977).

The South has a slightly larger relative area owned by the forest industry (18 percent) than the U.S. (14 percent). Importantly, the growth in forest industry ownership in the U.S.

TABLE 9-19: OWNERSHIP OF COMMERCIAL FOREST IN 1977
(thousand acres)

State	Federal	State	County & City	Indian	Private
Region 4					
Alabama	800	156	53		20,324
Florida	1,616	466	26	7	13,215
Georgia	1,417	94	34		23,268
Kentucky	819	76	.6		11,007
Mississippi	1,202	95	377	14	15,204
North Carolina	1,319	320	78	46	17,799
South Carolina	862	206	27		11,081
Tennessee	919	324	22		11,555
Total	8,954	1,736	619	67	123,452
Region 6					
Arkansas	2,718	237,	20		15,233
Louisiana	694	299	10		13,525
New Mexico	2,867	171		573	1,927
Oklahoma	348	91	15	115	3,755
Texas	737	49	7	3	11,717
Total	7,363	846	51	690	46,156
Sunbelt Total	16,317	2,582	670	757	169,608
U.S.	99,655	23,642	7,216	6,089	351,124

Source: USDA, Forest Service, 1977.

increased by nearly 8 million acres, much of it in the South (USDA, Forest Service, 1977). By 1970, the southern forest products industries owned more than 35 million acres. About 9 million acres in the region were also leased by forest industries at that time.

C. Existing Demand and Harvest

In the last three decades, consumption of most timber products in the U.S. has risen in response to increases in population, economic activity, and income (Hair, 1980). By 1978, total softwood lumber use was 25 percent above the 1950 level while pulpwood consumption increased nearly fourfold in the same period. At the same time, hardwood plywood use grew 300 percent and softwood plywood use jumped about 700 percent. The combined volume of lumber, veneer and plywood, pulpwood, and other industrial timber products rose from nearly 10 billion cubic feet in 1950 to about 14 billion in 1978 (Hair, 1980).

On the whole, southern forests are very productive, providing, in 1970, half the nation's net growth in softwoods and more than one-third the total net growth in hardwoods (Table 9-20). In theory, the South could support an increased timber harvest, as harvest is still less than net growth. However, the harvest exceeds growth in some areas such as the north coastal plain of North Carolina and in southeast Georgia (Williston, 1979) apparently due to lack of reforestation (Weyerhaeuser, 1982). Other areas currently undergoing high cutting rates are southwest Alabama, south Mississippi, east Texas, and southwest Arkansas.

9.3.2 Future Developments

A. Future Demands for Timber

Demands for most timber products are likely to continue to grow rapidly (Table 9-21). For all timber products combined, the demand for roundwood[1] is estimated to reach 22.7 billion cubic feet in 2000 (Hair, 1980). Much of the increase is projected for pulp products; pulpwood constituted about one-third of the demand for roundwood in 1976 and is expected to comprise up to 45 percent of roundwood demand in 2000 (see Chapter 10).

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[1] Roundwood refers to timber that is to be delivered to a mill in relatively whole form as logs. It is contrasted to delivery of wood fiber or tree chips. However, roundwood can be subsequently processed to chips, pulp or other nonsolid wood products.

TABLE 9-20: NET ANNUAL GROWTH AND REMOVAL OF GROWING STOCK, 1976
(billion cubic feet)

Source	Net Growth	Removals	Ratio of Growth to Removals
North			
All species	5.3	2.5	2.1
Softwoods	1.6	0.7	2.2
Hardwoods	3.8	1.8	2.1
Rocky Mountains and Great Plains			
All species	1.7	0.9	2.0
Softwoods	1.6	0.8	1.9
Hardwoods	0.1	<.05	5.8
Pacific Coast			
All species	3.5	4.2	0.8
Softwoods	2.9	4.0	0.7
Hardwoods	0.5	0.1	4.3
South[a]			
All species	11.1	6.7	1.7
Softwoods	6.2	4.5	1.4
Hardwoods	4.9	2.2	2.2
Total U.S.			
All species	21.7	14.2	1.5
Softwoods	12.3	10.0	1.2
Hardwoods	9.4	4.2	2.2

Source: Calculated from USDA, Forest Service, 1980, p. 376.

[a] The South corresponds to the Sunbelt states, plus Virginia and Puerto Rico, and less New Mexico.

TABLE 9-21: HISTORIC AND PROJECTED U.S. DEMAND FOR LUMBER AND PLYWOOD

	Lumber (million board feet)				
Source	1970	1976	1990	2000	2010
Softwoods	32,100	36,200	47,830	48,590	52,430
Hardwoods	7,300	6,500	10,120	11,290	12,880
Total	39,500	42,700	57,950	59,880	65,316
	Plywood (million square feet)				
	1970	1976	1990	2000	2010
Softwoods	14,038	17,135	23,670	24,280	26,590
Hardwoods	3,784	3,581	5,330	5,770	6,250
Total	17,822	20,716	29,000	30,050	32,840

Source: Compiled from USDA, Forest Service 1980, pp. 325-26. Projections made in 1973, using U.S. Forest Service "moderate" projections.

Increases in roundwood consumption in the 1960's and 1970's came entirely from softwood species. Now however, both softwoods and hardwoods are projected to show large increases in demand. This demand is likely to increase harvesting from domestic forests, since imports of forest products have been relatively small. The situation may be aggravated by the trend during the past decade of conversion of forest areas to urban and cropland use.

Production pressures in the South may further be intensified by substantial production declines on the Pacific Coast. Because industry lands physically are unable to maintain current rates of cutting, Pacific softwood sawtimber[1] supplies are projected to drop from 25.2 to 20.5 billion board feet (1976-2010), with most of the compensating increase expected to come from farm and other private, nonindustrial forest land in the South. The South's share of total U.S. softwood supply is expected to rise from 42 percent in 1970 to about 50 percent by the year 2000 (Table 9-22).

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[1] Sawtimber is timber delivered to a mill that meets minimum dimensions useful for lumber, typically 8 to 12 feet long, and at least 7 to 11 inches in diameter.

The U.S. Department of Commerce, Bureau of Economic Analysis projects tremendous increases in lumber products industry earnings (excludes pulp and paper earnings) by 2010, (Table 9-23). Eastern Texas, for example, has a large acreage of pine forest which is beginning to be cut at a high rate and earnings should more than triple by 2010.

B. Future Supplies

The projected demand for timber products estimated by the Forest Service shows increases much larger than growth in timber supplies, with softwoods showing the largest shortfall between supply and demand. Probable increases in prices of logs and timber products may cause significant adverse effects on primary timber processing industries, timber industry employment, timber inventories, consumers of wood products, and the environment (Hair, 1980). As prices rise, harvest may increase initially, followed by slackening demand and increasing supplies as prices continue to rise. The largest impacts of any increased harvest will be felt in the South. Price rises also may cause shifts to competitive materials such as steel and plastics (USDA, Forest Service, 1977).

C. Change in Forests and Practices

There is a concern in industry that without proper management logged stands regenerate in hardwoods rather than pines. Thus, there has been an average loss of approximately 500,000 acres of pine forest each year, as harvested stands grow up again in oak-pine and oak-hickory woods (Williston, 1979). Mississippi lost about 275,000 acres of pine between 1967 and 1977.

The industry considers hardwoods inferior because fibers are too short for paper, it has a tendency to warp, and most of them grow slowly, are shorter than pines, and much of their volume is in small stems (Sternitzke, 1978). Unless areas of hardwoods are cut, the South may fall short of its expected timber production. However, such discussions about "full productivity" ignore the value of forest land for uses other than timber production.

Industry-owned land has apparently been cut at rates faster than it can now regenerate, causing the timber industry to expand activities onto large areas of leased land. The softwood timber cut on timber industry land, for example, apparently exceeds growth by 21 percent (U.S., CEQ, 1979). As timber production in

TABLE 9-22: PROJECTED ROUNDWOOD AND SAWTIMBER SUPPLIES IN THE SOUTH AND THE U.S.

	Roundwood supplies (million cubic feet)			
	1970	1990	2000	2010
South[a]				
Softwoods	3,531	4,887	5,392	5,774
Hardwoods	1,833	2,732	3,466	4,117
Total	5,364	7,619	8,858	9,891
U.S.				
Softwoods	8,701	10,369	11,058	11,607
Hardwoods	3,391	4,886	6,027	7,065
Total	12,092	15,255	17,085	18,672

	Sawtimber supplies (million board feet)			
	1970	1990	2000	2010
South[a]				
Softwoods	14,225	19,404	21,867	24,068
Hardwoods	6,225	8,798	11,442	13,804
Total	20,450	28,202	33,309	37,874
U.S.				
Softwoods	46,097	48,115	50,454	52,517
Hardwoods	12,414	14,713	18,460	21,889
Total	58,511	62,828	68,914	74,406

Source: Compiled from USDA, Forest Service, 1980, pp. 382-85.

[a] Includes Sunbelt states plus Virginia and Puerto Rico, less New Mexico.

TABLE 9-23: PROJECTED GROWTH IN LUMBER PRODUCTS INDUSTRY EARNINGS[a]
(millions of 1972 dollars)

Region/State	1969	1978	1990	2000	2010	Percent Change 1978-2010
Region 4						
Alabama	159	243	391	533	705	190
Florida	102	179	287	396	528	196
Georgia	170	237	370	496	649	174
Kentucky	62	90	129	164	207	129
Mississippi	155	207	343	462	605	192
North Carolina	199	274	350	395	457	67
South Carolina	92	125	188	244	313	150
Tennessee	117	154	205	239	284	84
Total	1,056	1,509	2,262	2,930	3,748	148
Region 6						
Arkansas	143	184	269	340	427	132
Louisiana	111	145	203	256	321	122
New Mexico	16	25	42	58	76	202
Oklahoma	15	40	67	96	130	227
Texas	158	313	548	778	1,053	236
Total	443	707	1,130	1,527	2,007	148
Sunbelt Total	1,499	2,216	3,392	4,458	5,755	160
U.S. Total	4,864	7,375	10,975	14,149	18,048	145

Source: Data calculated from U.S., Dept. of Commerce, BEA, 1980.

[a] Excludes furniture earnings.

the study area increases, greater attention may be directed to the specific interest of private leases. For example, the desires of many owners for aesthetically pleasing woods and for diversity of forest types and conditions may cause a return to partial cutting and maintaining a wide range of tree sizes (all-aged management as opposed to clear cutting and even-aged management) on some small holdings (Williston, 1979).

The forestry industry is likely to be affected by a range of developments including changed housing markets, increased demand, reduced forest acreage, and new forest leasing and ownership patterns. A range of technological developments also may affect forestry economics and impacts. These include:

- New silviculture methods and stocking practices, including genetically engineered tree seedlings with increases in growth potential under a wider range of environmental conditions. These stocks may have the effect of reducing pest susceptibility, and utilizing low fertility soils;
- Reduced runoff and enhanced control of road building and maintenance programs;
- New log extraction methods, soil moisture control and soil fertilizing methods; and
- New pesticides that reduce application requirements. Herbicides and insecticides are now applied only during specific periods or events, and reduced applications are possible.

9.3.3 Environmental Impacts of Timber Industry Activities

By the end of the century the South is expected to account for approximately half the annual softwood roundwood supply and 45 percent of the hardwood supply. Forest management and harvest activities have several impacts which will be exacerbated by the intensification of production and harvest. Impacts are related to road construticon, pest control, growth enhancement, site preparation, and methods of harvest (U.S., EPA, 1978).

One of the most significant impacts is erosion that comes from site preparation, road construction, and road maintenance in logging areas. Particularly when poorly designed, road construction can increase soil erosion and consequent stream sedimentation. Erosion rates at harvest can be substantially greater than for cropland, for example, depending on the kind of harvest and regeneration practiced (Conner, Travis, and Trudeau, 1980; see Chapter 12). In addition, mechanized forestry operations can compact the soil which may lead to reduced infiltration and increased runoff. Recovery from compaction can take three to ten years or longer when soil does not undergo freezing and thawing (as is the case in parts of the South) (U.S., EPA, 1980, p. 396). Compaction typically can be corrected by mechanical scarification (Weyerhaeuser, 1982).

Pesticides and fertilizers generally are applied to forest lands at infrequent intervals. In a 30 to 80 year growth period, each forest area may receive two or three applications. Herbicide treatments or mechanical means may be used to prevent the regeneration of hardwoods after pines have been harvested. If not done with care, aerial herbicide applications can contaminate forest streams and, if not carefully timed, fertilization can result in nutrient runoff. Use of pesticides in forest management will continue to be an important policy issue, especially in the future as privately owned woodlands in the study area are expected to assume a relatively larger proportion of regional and national timber harvests.

Timber harvest methods have important environmental impacts. Clear-cutting is expected to increase in the South along with shorter rotations (periods between harvests). This could have adverse effects for soil erosion and stream siltation. Clear-cutting also disrupts wildlife habitat and food supplies, although after a period of revegetation, low brush often provides a better food supply for animals such as deer. Changing the composition of forests also affects wildlife species. Harvests of pine forests without subsequent management has resulted in conversion to hardwoods and mixed forest types. Many areas of hardwoods or mixed hardwood-pine forest have been converted to pine forest, and industry is interested in further conversions. Conversion of mixed stands to pine plantations may have minimal adverse environmental effects (U.S., EPA, 1977), but is attractive mainly from an industry production viewpoint.

New technologies and better harvest management could lessen the environmental impacts of silviculture. For example, land with fragile soil or steep terrain could be withdrawn from road construction. Biological pest control, if available in the near future, could help reduce both mechanical and chemical treatments of forest insects and disease.

An additional concern is the global increase in atmospheric carbon dioxide (CO_2) which has been related to the cutting of large areas of forest throughout the world as well as to the burning of fossil fuels. Due to the relatively small timber harvest in the South, only a slight impact on this problem is likely in the coming decades. If better success at stand regeneration is achieved, these forests could help reduce increases in global CO_2.

9.4 SUMMARY

Forestry and agriculture are locally important economic forces accounting for about 5 to 6 percent of industrial earnings in much of the Sunbelt, but have economic multiplier effects in other industries, such as the pulp and paper industry, and food processing. States in the South vary greatly in the importance of specific products or crops. For example, cattle are the largest agricultural commodity (as cash receipts) in the Southern Plain states (New Mexico, Oklahoma, and Texas), soybeans are the most important in the Delta states (Louisiana, Arkansas, and Mississippi) and the Southeastern states have their largest cash receipts from oranges (Florida), broiler chickens (Alabama and Georgia), tobacco (Kentucky and Tennessee), and soybeans (South Carolina).

Cotton, however, is a key agricultural commodity for understanding trends in the Sunbelt. It ranks among the top three cash crops in Texas, Oklahoma, and Mississippi. But cotton production has moved from the Southeastern states to the Delta and Southern Plains states. In the plains states, cotton varieties do not require as much pesticide as in the Southeast. However, cotton acreage requires large applications of insecticide in the Delta and Southeast, and this has offset the reduction achieved in Texas and Oklahoma. Reduction in insecticides use has occurred on tobacco and peanut crops regionwide.

Soybeans are another key crop. Soybean production has increased dramatically in the past 20 years, so that by 1981 more cropland was planted to soybeans in the South than any other crop. Soybeans do not require much fertilizer and have minimized nutrient pollution to streams from fertilizer use, but about 25 percent of the soybean crop requires insecticide, especially in the Southeast.

Herbicide applications to southern crops have increased from about 19 million to 98 million pounds from 1964 to 1976. Most of the increase in herbicides has been to corn and soybeans. Delta states of Louisiana, Arkansas, and Mississippi apply the most herbicides, and the Southern Plains states and New Mexico apply the least.

Most agricultural sectors have increased significantly in output during the past decade, and are projected to continue in the future. Feed grains for export represent a major projected agricultural crop increase. Softwood production from loblolly pines is expected to continue to be the major forest output.

Future environmental concerns include land conversion conflicts involving forests, croplands and other uses, and a range of land and agricultural management issues involving erosion protection, and herbicide and insecticide application. Insecticide application may be stabilizing or diminishing, but herbicide application may emerge as a major environmental control issue as herbicide use continues to expand.

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TABLE 9-A1: INSECTICIDE USE ON MAJOR FIELD CROPS, HAY, PASTURE, AND RANGELAND, BY AGRICULTURAL REGION[a] (1,000 pounds)

Crop	Appalachian			Southeast			Delta			Southern Plains		
	1964	1971	1976	1964	1971	1976	1964	1971	1976	1964	1971	1976
Corn	1,053	375	940	194	42	974	(b)	37	22	17	54	1,246
Cotton	4,999	3,610	4,092	23,774	27,259	20,581	23,530	20,323	32,653	20,797	10,320	2,461
Wheat	(c)	2	165	(c)	(b)	--	(c)	87	--	(c)	1,355	4,485
Sorghum	(c)	28	--	(c)	406	100	(c)	339	487	(c)	2,927	1,366
Soybeans	369	928	874	1,348	2,655	6,179	2,729	1,872	173	(b)	22	151
Tobacco	3,042	2,511	2,259	2,273	1,467	900	--	--	--	--	--	--
Peanuts	(c)	1,071	1,133	(c)	3,835	1,049	(c)	--	--	(c)	1,084	257
Rice	(c)	--	--	(c)	--	--	(c)	91	82	(c)	726	426
Other grains	(c)	10	--	(c)	3	31	(c)	36	--	(c)	404	1,428
Alfalfa, hay, and forage	(c)	170	85	(c)	--	310	(c)	24	236	(c)	88	1,073
Pasture and range	2,400	--	1	4,504	31	1	629	34	57	760	93	50
Totals	11,863	8,705	9,549	32,093	35,698	30,125	26,888	31,846	33,710	21,574	17,073	12,943

Sources: Data compiled from Eichers, Theodore R., et al. 1968. Quantities of Pesticides Used by Farmers in 1964, Agricultural Economic Report No. 131. Washington, D.C.: Government Printing Office; Eichers, Theodore R., et al. 1978. Farmers' Use of Pesticides in 1976, Agricultural Economic Report No. 418. Washington, D.C.: Government Printing Office; Andrilenas, Paul A. 1974. Farmers' Use of Pesticides in 1971--Quantities, Agricultural Economic Report No. 252. Washington, D.C.: Government Printing Office.

[a] Appalachian: Kentucky, Tennessee, North Carolina, West Virginia, Virginia; Southeast: Alabama, Georgia, South Carolina, Florida; Delta: Arkansas, Louisiana, Mississippi; Southern Plains: Texas, Oklahoma.

[b] Less than 500 pounds.

[c] The 1964 report combines wheat, sorghum, rice, peanuts, mixed grains, hay, alfalfa, pasture and other miscellaneous field crops. The totals are given under "Pasture and range."

TABLE 9-A2: HERBICIDE USE ON MAJOR FIELD CROPS, HAY, PASTURE, AND RANGELAND, BY AGRICULTURAL REGION[a]
(1,000 pounds)

	Appalachian			Southeast			Delta			Southern Plains		
Crop	1964	1971	1976	1964	1971	1976	1964	1971	1976	1964	1971	1976
Corn	1,937	6,166	19,086	502	2,105	8,126	192	474	387	22	127	1,664
Cotton	479	1,039	750	586	3,045	1,039	2,465	9,649	11,562	985	3,952	2,761
Wheat	21	15	84	(b)	18	(b)	(b)	--	55	43	144	983
Sorghum	26	310	1,502	29	125	53	--	287	420	406	3,486	4,097
Soybeans	225	3,042	8,211	15	1,233	6,371	372	9,011	15,241	--	99	11
Tobacco	1,699[c]	*	821	1,332[c]	*	311	(b)[c]	*	--	29[c]	--	--
Peanuts		1,431	999		2,669	2,073		5	--		266	285
Rice	18[d]	--	--	18[d]	--	--	1,431[d]	4,450	6,163	2,913[d]	2,646	2,289
Other grains		--	131		7	13		--	--		30	77
Alfalfa, hay and forage	246[e]	27	10	388[e]	35	54	342[e]	66	9	1,733[e]	42	285
Pasture and Range		167	207		161	11		248	84		4,223	1,952
Totals	4,651	12,197	31,801	2,870	9,398	18,051	4,802	24,190	33,921	6,131	15,015	14,404

*Amount not disaggregatable.

Sources: Data compiled from Eichers, Theodore R., et al. 1968. Quantities of Pesticides Used by Farmers in 1964, Agricultural Economic Report No. 131. Washington, D.C.: Government Printing Office; Eichers, Theodore R., et al. 1978. Farmers' Use of Pesticides in 1976, Agricultural Economic Report No. 418. Washington, D.C.: Government Printing Office; Andrilenas, Paul A. 1974. Farmers' Use of Pesticides in 1971--Quantities, Agricultural Economic Report No. 252. Washington, D.C.: Government Printing Office.

[a] Appalachian: Kentucky, Tennessee, North Carolina, West Virginia, Virginia; Southeast: Alabama, Georgia, South Carolina, Florida; Delta: Arkansas, Louisiana, Mississippi; Southern Plains: Texas, Oklahoma.

[b] Less than 10,000 pounds.

[c] Includes tobacco, peanuts, sugar cane, grass and hay seed, and other less important field crops.

[d] Other grains includes rice.

[e] Pasture, range, alfalfa, and hay.

CHAPTER 10

THE PULP AND PAPER INDUSTRY

HIGHLIGHTS

- Status and Trends

1. During the past decade the pulp and paper industry has invested in pollution control equipment which resulted in reductions in discharges to air and water. Significant improvements in fisheries and water quality have accompanied these investments.

2. The pulp and paper industry, an important component of many local economies in the southern region, can be expected to grow significantly, both by construction of new mills and by added capacity to existing plants. This growth may be accompanied by economic benefits, but also by increased water consumption and by possible added discharges, depending on levels of environmental control.

- Geographic Areas

3. The industry in the South is largely concentrated in Alabama, Georgia, and Louisiana. Other states with major pulp mill activity are Florida, the Carolinas, Mississippi, Texas, and Arkansas. New growth in plant capacity is especially important in Region 4 as well as Texas and Louisiana.

4. Although both the Atlantic and Gulf coastal zones have been the location of many mills, new mills may be constructed mostly inland.

5. Most mills have improved pollution control performance, and well documented improvements in water quality have been made in several instances, including the Pearl River in Louisiana, Perdido Bay in Florida and Alabama, and Escambia Bay in Florida.

- Key Problems and Issues

6. Water, air quality, and hazardous waste regulations are under review. Further environmental controls, such as increasing standards from 85 percent BOD removal to 90 percent removal are uncertain. More stringent standards would require significant new capital expenditures if compliance with any new regulation is to be achieved.

7. Local nuisance from emissions of odorous compounds to the atmosphere and discharges of oxygen-demanding substances to receiving streams is likely to continue, although at levels lower than the previous decade.

CHAPTER 10

THE PULP AND PAPER INDUSTRY

10.1 INTRODUCTION

As indicated in Chapter 4, compared with other major manufacturing industries, the size of the pulp and paper industry in the Sunbelt ranks near the midrange in terms of earnings to labor. However, the industry has been predominantly concentrated in the South for the past 30 years, and is most important in Georgia, Louisiana, Alabama, and Florida. At locations of pulp and paper mills, entire communities are often economically dependent upon this one industry. Due to its use of large quantities of water and the large quantities of wastewater discharge, the mills can have substantial local environmental impact, particularly in terms of oxygen demanding substances discharged to streams and rivers.

This chapter examines the current status, regional trends, and environmental impacts of the pulp and paper industry. The introduction describes the components of the industry and provides a brief overview of pulp and paper making processes. This is followed by an examination of the current status of the industry and growth trends. The third section discusses environmental concerns, including water quantity, water quality, air emissions, and toxic effluents.

10.2 PULP AND PAPERMAKING PROCESS[1]

Pulp and paper mills vary in the range of processes and activities included at the mill site. Integrated mills are mills that produce pulp and paper and paperboard products at the same site. Waste paper is the raw material in secondary fiber mills. Finally, nonintegrated mills purchase wood pulp from pulp mills and produce paper or paperboard products.

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[1] Two different types of classification of the pulp and paper industry are used in this chapter: Standard Industrial Classification (SIC) codes and the subcategories used by the Environmental Protection Agency (EPA). The SIC system classifies the components of the pulp and paper industry by product type. Three general categories emerge: pulp (2611), paper (2621, 2631, and 2661) and converted paper (264 and 265). As indicated, vertical integration among these categories is common for industrial facilities in these classifications.

Wood pulp is produced in four main steps: (1) wood preparation (debarking and chipping), (2) cooking, (3) screening and washing, and (4) bleaching (if desired). In the first step, whole logs are prepared by a sequence of washing, debarking, and chipping operations. The processes vary depending on the form of raw materials used (Federal Register, 1981). Often entire mills are run from the residue of logs that were manufactured into lumber and other wood products.

The second step of pulping reduces wood chips or wastepaper into fiber. This "cooking" or pulping process involves combinations of mechanical and/or chemical processes. Pulp is often prepared mechanically by pulverizing wood or softened chips into fiber bunches, which are then matted and dried into pulp sheets. Chemicals typically are not used in this mechanical "groundwood" process. The paper product, however, is brittle, nondurable, and fades in direct sunlight. Groundwood pulp generally is used in combination with other pulp types for products such as newsprint and corrugated paper (Allan et al., 1972).

Chemical processes include sulfate, semichemical, and sulfite. As shown in Table 10-1, sulfate (kraft) pulping is the most common in the South. In this process, wood chips are mixed with an alkaline liquor solution and cooked with steam under high temperatures and pressures. Kraft mills burn the spent cooking solutions after the pulp has been extracted to recover chemicals for reuse and to generate heat for the process. The semichemical process mixes both chemical and mechanical pulping methods. The sulfite process involves soaking wood chips in a sulfurous acid solution and cooking under high temperature and pressure. Most environmental impacts of the pulp and paper industry are the result of the pulping process (Allan et al., 1972).

The pulp is then screened and washed at the third step, with screened materials repulped or discarded. If white pulp is desired, the pulp is bleached in a fourth step through the use of chemicals which include chlorine, chlorine dioxide, and hydrogen peroxide with various washing steps and extraction steps using sodium hydroxide between the bleaching steps. Frequently, the bleaching process includes three to six stages depending upon what whiteness and fiber properties are desired.

In secondary fibers mills, wastepaper is the primary raw material. Currently, wastepaper meets 25 percent of demand for raw materials for paper and paperboard production (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980). Not much pulp, less

TABLE 10-1: SOUTHERN[a] PULPING CAPACITY BY PROCESS TYPE (1978 tpd)

Process	Capacity	Percent
Sulfate	77,502	81
Groundwood	11,468	12
Semi-chemical	6,202	6
Soda and Sulfite	650	1
Total	95,822	100

tpd = tons per day

Source: Computed from Bertelson, 1979.

[a] Study area excluding Kentucky and New Mexico.

than 5 percent, is made from wastepaper, however. Incentives for wastepaper recycling into pulp may increase.[1]

In secondary fibers mills, wastepaper is shredded and cooked. Some paper products require additional deinking. Ink can be removed by detergents and other chemicals. After screening and washing, the processed stock is then stored (Federal Register, 1981).

In all types of mills (integrated, secondary fibers, and nonintegrated), the pulp is normally resuspended in a water slurry by hydraulic pulping, which eliminates steam and chemical requirements, and a sheet is produced. The sheet can be coated with other materials to achieve specific properties. These coating materials include starch, clay, titanium dioxide, and urea formaldehyde resins. The stock is then mechanically and chemically processed into paper or board (Federal Register, 1981).

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[1] The National Energy Act, for example, provides tax credits for recycling equipment purchases and the Resource Conservation and Recovery Act encourages wastepaper recycling and use (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980).

10.3 CURRENT STATUS

In comparison with 19 other two-digit SIC industries during 1977, the pulp and paper industry ranked 13th in terms of employment with 625.5 thousand workers, and 9th in terms of value of shipments, at $51.7 billion. These figures represent 3 percent and 4 percent of the total number of workers and value of shipments in manufacturing, respectively (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980). The U.S. pulp and paper industry produces a large proportion of the world's pulp and paper; about 43 percent of total production of paper products and pulp in 1978 (OECD, 1980). A narrowing balance of trade deficit for pulp and paper has occurred in recent years. The value of pulp and paper imports in 1979 was 4.4 billion dollars while exports were 2.9 billion dollars (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980).

The foreign sector is especially important for pulp. In 1979, for example, imports of pulp represented 59 percent of U.S. pulp consumption, while pulp exports accounted for 48 percent of product exports (U.S., Dept of Commerce, Ind. & Trade Admin., 1980). This trade can be explained by locational factors; Canada supplies nearly all of the U.S. pulp and paper imports, with most of the pulp going to mills in the upper Midwest and Northeast. Exports, however, largely originate in the South and Northwest. Southern mills produced 55 percent of the U.S. pulp exports in 1970, while the Northwest produced 43 percent. Much of this was sold to Europe or Japan (Guthrie, 1972; Forest Products Review, 1980). Thus, the pattern of international pulp trade can affect the level of activity in the southern region.

On a regional scale a plentiful supply of inexpensive fiber has been a major factor in determining the location of the pulp and paper industry in the United States. When straw comprised 40 percent of paper content during the nineteenth century, the industry was concentrated in the Northeast straw producing areas. When wood supplanted straw as the primary feedstock at the turn of the century, paper production shifted to the Midwest (Guthrie, 1972). Many of the best timber stands in the Midwest were cut by 1919, causing a shift of the forest products industry to the South and Northwest. Consequently, the South has become the nation's leading pulp producing area since 1939 (Guthrie, 1972).

A major indicator of pulp and paper industrial activity is wood pulp production and in 1978 the U.S. produced 79.8 million standard cords of pulpwood. As indicated in Table 10-2 the southern states produced about 48 million cords of this total, the vast majority used by local mills. The pulpwood comes from roundwood (logs) as well as wood residues (see Chapter 9). Nationwide the supply of woodpulp from these wood sources has about doubled from 1960 to 1979 (see Table 10-3). The South

TABLE 10-2: PULPWOOD PRODUCTION IN THE SOUTH, 1978
(thousands of cords)

State	Production
Alabama	7,354
Arkansas	3,948
Florida	3,671
Georgia	8,908
Louisiana	4,306
Mississippi	5,530
North Carolina	4,639
Oklahoma	614
South Carolina	4,307
Tennessee	688
Texas	4,033
Total[a]	47,997

Source: Bertelson, 1979

[a] Total may not agree due to rounding factor.

TABLE 10-3: WOODPULP SUPPLY AND CONSUMPTION
(Millions of short tons)

Item	1960	1965	1970	1979
Production total	25.3	34.0	43.5	52.7
Sulfate	14.6	21.5	29.5	38.0
Groundwood	3.3	3.6	4.4	4.4
Imports	2.4	3.1	3.5	4.3
Exports	1.1	1.4	3.1	2.9
Consumption in paper and board	25.7	34.0	43.2	51.7
Total supply[a]	26.6	35.7	44.0	54.1

Source: U.S., Dept. of Commerce, Bur. of Census, 1980a.

[a] Production plus imports, less exports. Production includes other, not shown separately.

(including Maryland and Virginia) accounted for 64 percent of the nation's pulp production in 1970, 38 percent of its paper, and 59 percent of its paperboard (Guthrie, 1972). As shown in Table 10-4, the South accounted for 68 percent of U.S. pulp capacity in 1977. Most of the Sunbelt's mill capacity is located in Region 4, particularly in Georgia, Alabama, and Florida. Within Region 6, Louisiana contains the greatest mill capacity. Together these four states account for 56 percent of the Sunbelt's capacity.

The distribution of pulp mills in the South is shown in Figure 10-1. The industry has located many plants along the coastline, taking advantage of inexpensive water transportation for pulpwood, abundant water supplies for the pulping process, and access to foreign markets. New plant construction however,

TABLE 10-4: SOUTHERN PULP MILL CAPACITY, 1977

Region/State	Capacity (tpd)	Percent of U.S. Capacity[a]
Region 4		
Georgia	15,234	
Alabama	12,880	
Florida	10,390	
South Carolina	7,907	
North Carolina	6,810	
Mississippi	6,470	
Tennessee	4,015	
Total	63,706	46
Region 6		
Louisiana	13,470	
Texas	7,440	
Arkansas	6,050	
Oklahoma	2,970	
Total	29,930	22
Total U.S. Capacity	137,700	

Source: Bellamy, 1978; U.S., Dept. of Commerce, Ind. & Trade Admin., 1980

[a] Percent of U.S. pulp production included in SIC Code 2611.

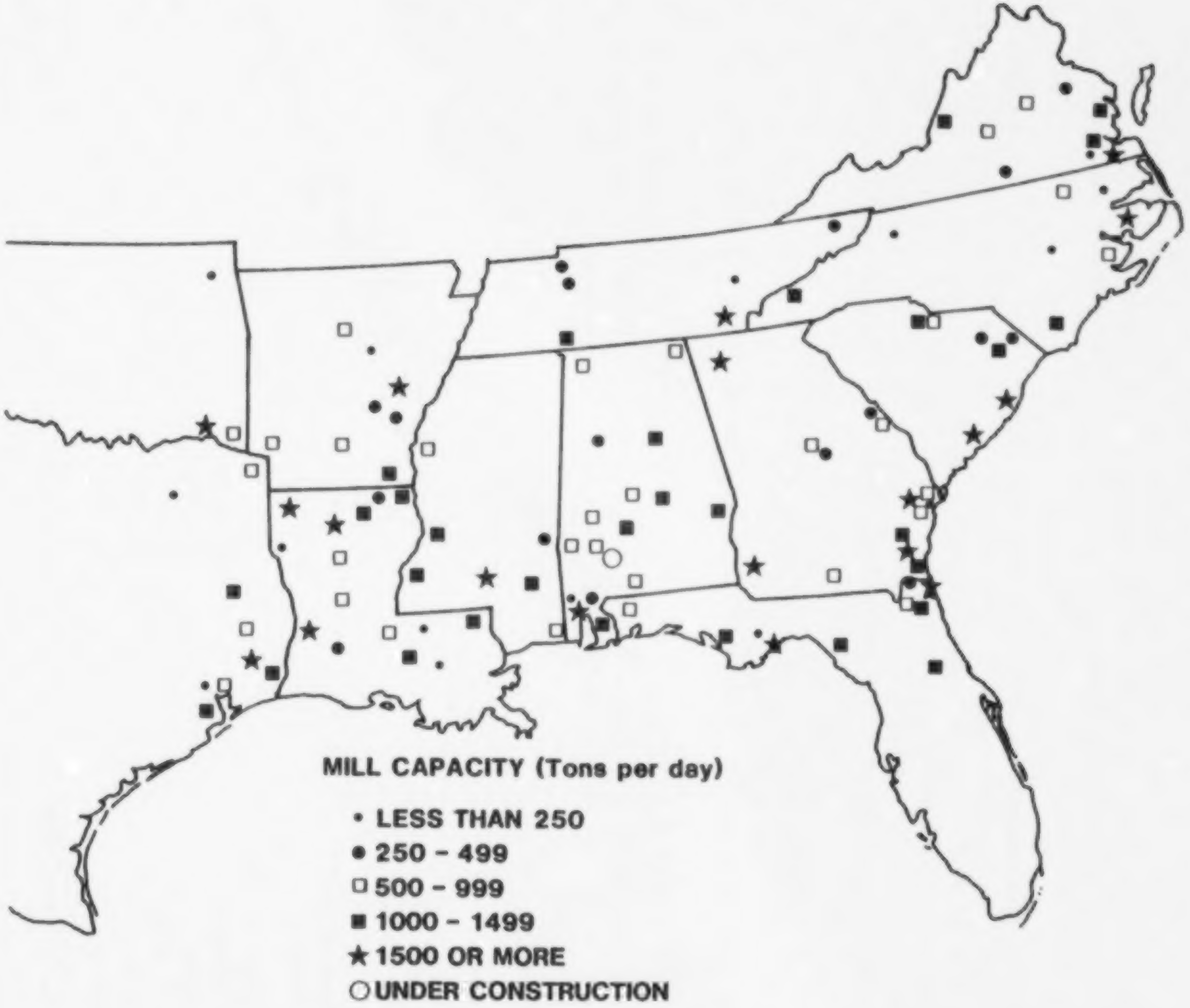

Figure 10-1: Southern Pulp Mills in 1977

Source: Bellamy, 1978

may occur inland for three reasons: first, desirable coastal sites have already been taken; second, coastal sites are restricted by Coastal Zone Management Planning (see Chapter 12); and third, the southern hardwoods--whose use in pulping has increased greatly in recent years--are more concentrated inland (Guthrie, 1972). New pulp mill construction inland has generally substantiated this pattern. However, some existing coastal mills may continue to add capacity in the future utilizing the wood supply of the South.

Paper and board production in the South also is a large proportion of national output. As shown in Table 10-5, southern paper and board output represents at least 42 percent of national production. Not surprisingly, the ranking of states according to production levels is nearly identical to that for southern pulp capacity (U.S., Dept. of Commerce, Bur. of Census, 1979).

TABLE 10-5: PAPER AND BOARD PRODUCTION, 1978

Region/State	Output (million tpd)	Percent of U.S. Production
Region 4[a]		
Georgia	13,671	
Alabama	11,424	
Florida	7,123	
North Carolina	6,465	
South Carolina	6,411	
Tennessee	4,849	
Kentucky	NR	
Mississippi	NR	
Total	49,943	28
Region 6		
Louisiana	10,438	
Texas	6,383	
Arkansas	5,534	
Oklahoma	2,794	
Total	25,149	14
U.S. Production	176,164	

NR = Not reported to avoid disclosures for individual plants

Source: U.S., Dept. of Commerce, Bur. of Census, 1979.

[a] Includes Maryland

10.4 FUTURE DEVELOPMENTS

This section examines the potential for growth of the pulp and paper industry in the Sunbelt. Major factors affecting growth, including demand, energy costs, investment, and research are discussed first. Projections of future output are then considered.

10.4.1 Supply and Demand for Paper and Board

As shown in Table 10-6, the U.S. consumed 36.2 million tons of paper in 1978. The largest single category of consumption was newsprint at 11.2 million tons. Paperboard consumption was 27.9 million tons. Although variations in demand for paper and board are considerable in the short-run of one to two years, the overall growth in consumption for paper and board has been relatively consistent--about 43 percent between 1965 and 1978.

While overall demand for paper and paperboard products is likely to rise, demand for specific paper products may rise or fall. Newsprint capacity, for example, has been projected to increase, reducing the country's reliance on imports. The market share of nondeinked secondary fiber mill production is expected to decline, however. Despite incentives for recycling, rising costs have placed these mills at a competitive disadvantage with

TABLE 10-6: CONSUMPTION OF PAPER AND BOARD

Product Category	Consumption 1978 (million tons)	Percent Change 1965 - 1978
Total paper	36.2	44
Newsprint	11.2	33
Coated printing	4.6	64
Book paper and other printing, writing	10.6	65
Packaging and converting	5.8	21
Tissue and sanitary	4.2	45
Paperboard	27.9	42
Total paper and board	70.4	43
Construction paper and board	6.2	51

Sources: U.S., Dept. of Commerce, Bur. of Census, 1980a.

the larger virgin fiber mills (Federal Register, 1981). Long term changes in the availability of pulpwood, such as a shortage of roundwood (timber) or residue would reduce or change the competitive position of these process types.

10.4.2 Investment

Paper industry capital outlays have been projected to increase by 40 percent to 4 to 5 billion dollars, more than triple the average growth rate for all industries (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980). Some of the proposed spending involved construction of offices and research facilities, but a high proportion represented investment in new capacity in the primary products sector. Investment tax incentives and growing imports may weigh heavily in the upward revisions in investment planning (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980).

Capacity in the pulp, paper, and board segments, which normally take around two-thirds of the industry's total investment were scheduled to increase by 3 percent in 1980 (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980). This rate compares with an average of 2 percent annually in the 1970's and 4 percent in earlier post-World War II years.

Capital spending for environmental controls in the pulp and paper industry peaked during the mid 70's and has declined somewhat from these earlier levels. In the mid 1970's for example, nearly 30 percent of capital spending was allocated to pollution control. Capital spending on pollution control was about 296 million dollars, or about 7 percent of total capital spending in 1979 (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980). About 15 percent of capital outlays in pulp mills is expected to be spent on pollution control for new facilities and for expansion and modifications in the next few years (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980).

The magnitude of capital spending on pollution control in the pulp and paper industry is presented in Figure 10-2 (U.S., Dept. of Commerce, Bur. of Census, 1980b). Capital spending has been roughly evenly divided between water, on the one hand, and air and solid waste on the other.

The EPA expects some plant closures even without the addition of more pollution controls. These closures of marginal and older mills will likely be due to changes in product demand and rising costs. Production lost by these closures will be compensated by increased capacity utilization and modernization of existing mills. Because of the cost and availability of land and the resources involved in locating new mills, the EPA projects that most industry expansion will occur at existing plants (Federal Register, 1981).

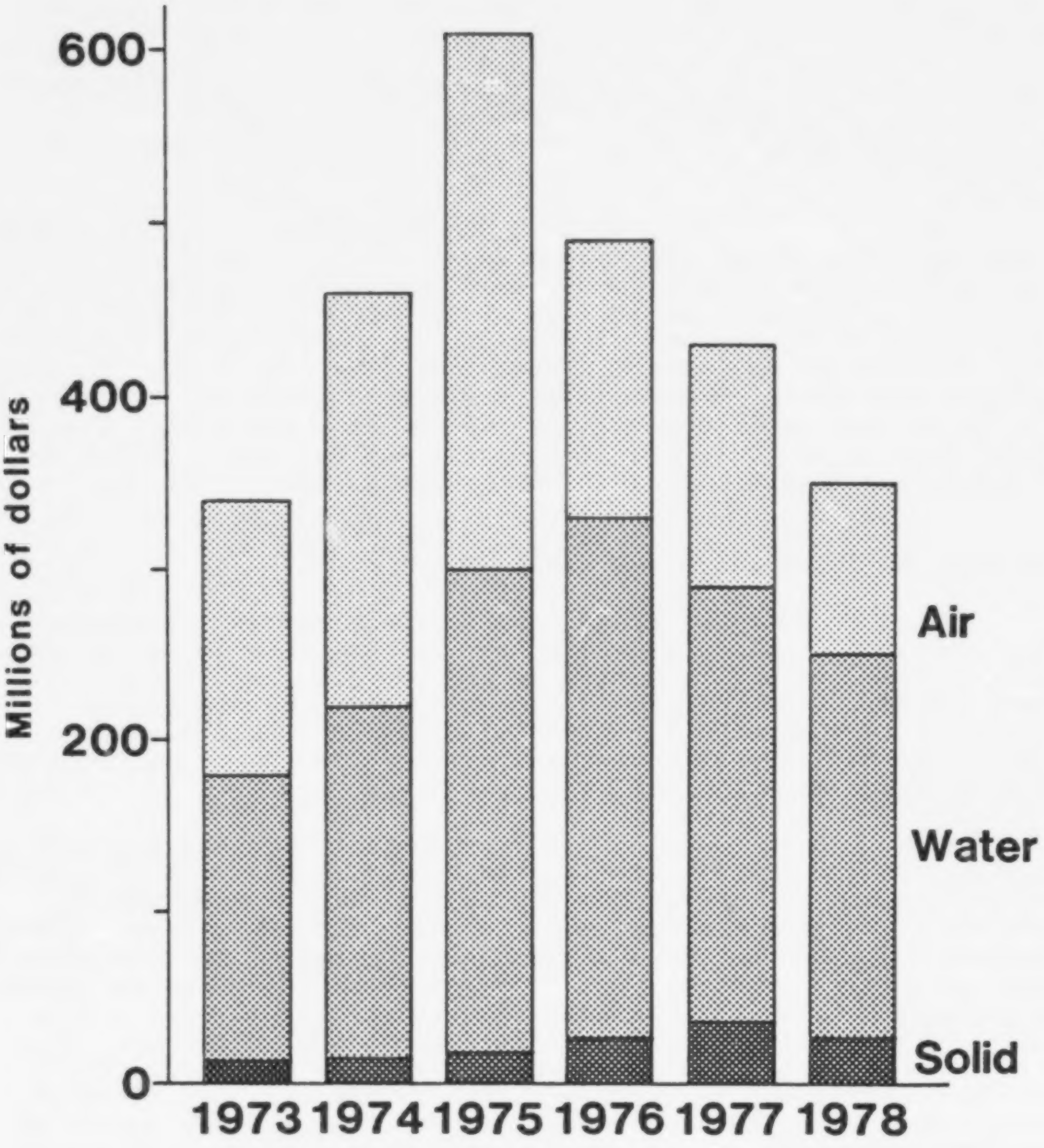

Figure 10-2: Capital Expenditures for Pollution Abatement, 1973-1978.

Source: U.S., Dept. of Commerce, Bur. of Census, 1980.

10.4.3 Energy Requirements

Pulp and paper mills are highly energy intensive. According to Industrial Outlook 1980, energy costs to the paper and pulp industry represent 6 percent of the value of product shipments. Only two industries (stone, clay and glass, and primary metals) are more energy intensive according to this measure. But this comparison only includes purchased energy; it does not include energy generated from byproducts such as wood residue, bark, and process liquids.

The paper and board mills in the South meet a larger proportion of their energy needs by consuming mill by-products than do mills nationwide (American Pulpwood Association, 1979). Mill by-products contributed an average of 55 percent of the energy requirements for paper and board mills in the South, as compared with an average 45 percent nationwide. The use of such biomass energy sources in paper and board mills is projected to increase by 70 percent from 1979 to 1984. Thus, it appears that the availability and cost of fossil fuels may be less a factor in determining future output in the industry than in the past.

10.4.4 Research and Development

The paper industry ranks comparatively low in its research and development (R&D) expenditures, although the industry benefits directly from its machinery and raw materials suppliers' R&D efforts. R&D focuses on improving new pulp technology. Spending remains at 1.5 percent of sales or 1 to 2 percent of operating and capital investment costs (U.S., Dept. of Commerce, Ind. & Trade Admin., 1980).

Recent R&D activities on improvements in pulping may make the processes more competitive through energy savings. Substantial attention has also been directed toward further adoption of sulfur-free oxygen pulping and bleaching and low-sulfur pulping technology which may have environmental benefits in reduced sulfur emissions. Through heat recovery technology, it has become practical to use the internally generated heat to heat boiler feed water, building space and the paper dryer sections. All these applications reduce externally purchased energy. These patterns of modest research effort may indicate that although improvements in efficiency and pollution control may occur, no major discoveries are expected in the future that would result in changes in industry location or overall level of activity.

10.4.5 Projections

Projections by the Bureau of Economic Analysis (BEA) indicate substantial growth in earnings of pulp and paper industry by 2010 for the southern region.[1] Table 10-7 shows that earnings are projected to nearly triple in Region 4 and quadruple in Region 6. The BEA projections predict Region 6 growing faster than some projections made by the EPA (U.S., EPA, ORD, 1980a). In BEA projections and those conducted by EPA, pulp and paper appears to be much more important in Region 4 than in Region 6.

10.5 ENVIRONMENTAL CONCERNS

10.5.1 Water Quantity

The pulp and paper industry withdraws and consumes large quantities of water.[2] Water is used in wood preparation, pulping, bleaching, and papermaking. It is used as a medium of transport, a cleaning agent, and as a solvent and mixer.[3] In 1975, for example, 8.9 billion gallons per day (bgd) were withdrawn by the industry, making pulp and paper the third largest among manufacturing water users (U.S., WRC, 1978) (see Chapter 13).[4]

As shown in Table 10-8, approximately one-fourth of 1975 water withdrawals and consumption in the paper industry occurred in the South Atlantic-Gulf water resource region (an area approximately equivalent to Region 4). Total 1975 withdrawals and consumption by paper manufacturing in Regions 4 and 6 were approximately 3,454 bgd and 379 bgd, respectively (U.S., WRC, 1978). Projections by the Water Resources Council indicate that the paper industry will become the largest water user among manufacturing industries by 2000, in terms of both withdrawals and comsumption (U.S., WRC, 1978).

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[1] BEA projections should be interpreted cautiously as extrapolations of past growth in the pulp and paper industry may be affected by competition with new products, imports and other economic uncertainties.

[2] Water "withdrawn" is that obtained from a source by a pipe or diversion. Water "consumed" is a part of that withdrawn which is then lost or used such as through evaporation or incorporation in a product and not returned to its source.

[3] Water withdrawals and discharges are very nearly equal in the pulp industries. The majority of the consumption comes from providing the pulpwood raw materials which is roughly 50 percent water.

[4] Chemicals and primary metals withdrew 19.4 and 18.9 bgd in 1975.

TABLE 10-7: PULP AND PAPER EARNINGS, 1978-2010
(millions of 1972 dollars)

Region/State	1978	2010[a]
Region 4		
Georgia	339	921
Alabama	274	708
North Carolina	252	667
Florida	203	417
Tennessee	194	617
South Carolina	174	510
Mississippi	90	205
Kentucky	77	280
Total	1,603	4,325
Region 6		
Texas	249	922
Louisiana	215	598
Arkansas	158	573
Oklahoma	26	341
New Mexico	1	2
Total	649	2,436

Source: U.S., Dept. of Commerce, BEA, 1980.

[a] Note shift in ranking of Tennessee, South Carolina, Florida, Kentucky, and Mississippi from 1978.

An individual pulp and paper mill withdraws in the range of 30 to 300 million gallons of water per day, largely depending on size, process type and the wastewater control methods (Allan *et al.*, 1972). The average of 24 mills surveyed in 1971 withdrew 110 million gallons daily and the large pulp mills withdrew 230 to 300 million gallons of water. In the past about 30,000 gallons of water were needed per ton of pulp produced, but new mills use as low as 3,000 to 5,000 gallons per ton (Weyerhaeuser, 1982). Bleach mills are still higher than other new mills, requiring about 20,000 to 25,000 gallons of water per ton. As indicated in Table 10-8, although withdrawal is expected to diminish through improved plant efficiency, the large plants are expected to consume more water. On a local basis, this use may constitute a significant proportion of the flow of streams adjacent to the mills.

TABLE 10-8: FRESHWATER WITHDRAWALS AND CONSUMPTION
(million gallons per day)

	Withdrawal			Consumption		
River Basin Region	1975	1985	2000	1975	1985	2000
South Atlantic-Gulf	2,111	1,974	1,875	262	614	1,492
Ohio	224	151	133	23	46	101
Tennessee	381	268	246	41	85	196
Lower Mississippi	517	403	381	46	119	304
Arkansas-White-Red	200	125	110	30	50	86
Texas-Gulf	245	200	218	38	79	174
Rio Grande	0	0	0	0	0	0
Lower Colorado	15	18	26	3	8	22
Total U.S. (conterminous)	8,314	5,909	5,298	1,034	1,983	4,194
	Saline water use					
South Atlantic-Gulf	464			8		
Total U.S. (conterminous)	539			9		

Source: U.S., WRC, 1978, vol. 2, pt. III, p. 48.

10.5.2 Water Quality

Regulations controlling wastewater effluents are based on the requirements of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 and the Clean Water Act (CWA) of 1977. The FWPCA Amendment requirements included industrial control of effluents by use of the "best practicable control technology currently available" in 1977 and the "best available technology economically achievable" in 1983. Also applicable to the pulp and paper industry are New Source Performance Standards and pretreatment standards for discharges into publicly owned treatment works.

The EPA issued regulations concerning all of these standards in 1974 (39 FR 18742) and 1977 (42 FR 1398). However, the 1983 "best available technology economically acheivable" requirements were suspended, and a new category called "best conventional technology" was recently proposed and subsequently challenged in court. The court has ruled that EPA did not follow proper procedures in establishing the proposed "best conventional technology" regulations and must revise them.

Examples of changes proposed by EPA include withdrawal of nationwide regulations for the control of color of effluents and to allow states to control color on a case-by-case basis. In addition, EPA has proposed "best available technology economically achievable" to reduce zinc discharge and require the substitution of other agents that control slime growth on process equipment for the toxic pentachlorophenol and trichlorophenol now used. New regulations that largely address toxic effluents were issued in January 1981 (46 FR 1439).

Effluent limitations parameters have been issued regarding biochemical oxygen demand (BOD), suspended solids, and pH for all pulp and paper subcategories. Zinc is the only toxic pollutant currently under regulatory controls as shown in Table 10-9, although proposed regulations would include control of chloroform, trichlorophenol, and pentachlorophenol. Color and settlable solids are controlled in few of the pulp mill process types (U.S., EPA, Off. of Water and Waste Mgmt., 1980).

Over the near term significant concerns exist in the industry in meeting the national standards requiring 93 percent BOD removal by 1984. This is a 5 percent improvement over the current 88 percent removal requirement (U.S., Dept. of Commerce, Bur. of Census, 1980b). Industry has suggested that the incremental improvement may not be justified by the costs incurred (U.S., Dept. of Commerce, Bur. of Census, 1980b).

Although pulp and paper mills discharge a wide range of chemicals as indicated above, major concerns are the volumes of oxygen demanding substances and suspended solids. Oxygen demanding substances are especially important because they can result in lower oxygen concentration in streams, making them less suitable for fish. These chemicals and suspended solids also increase bacterial growth, reduce water clarity, and discolor water, potentially making streams unsuitable for municipal or recreational uses.

Pulp and paper has been the largest industrial source of BOD, generating about 20 percent (1.7 million tons) of total gross BOD generation in the U.S. in 1975 (U.S., EPA, ORD, 1980a). About half of this was generated by the larger and more common kraft mills. As shown in Table 10-10, historic data on both gross generation and net discharges of BOD vary according to the type of pulping process. The historic data cited above indicate a wide range in final discharge, for example, from 13 to 65 pounds of BOD per ton of pulp produced. Importantly, significant improvements in reducing this level of discharge have been achieved in the past decade as indicated in the lower discharge values from recent monitoring data (Table 10-11). However, even

TABLE 10-9: PROPOSED PULP AND PAPER MILL EFFLUENT GUIDELINES

Process Type	Conventional Pollutants [a] Settlable Solids	Toxic Pollutant Zinc	Nonconventional Pollutant Color
Integrated Segment			
Dissolving kraft	-	-	*
Market bleached kraft	-	-	*
BCT bleached kraft[b]	-	-	*
Alkaline-fine[c]	-	-	*
Unbleached kraft	-	-	x
Semichemical	-	-	x
Unbleached kraft and semichemical	-	-	x
Dissolving sulfite pulp[c]	-	-	-
Papergrade sulfite	-	-	-
Groundwood-thermo-mechanical	-	x	-
Groundwood-CMN papers	-	x	-
Groundwood-fine papers	-	x	-
Secondary Fibers Segment			
Deink	-	-	-
Tissue from wastepaper	-	-	-
Paperboard from wastepaper	-	-	-
Wastepaper-molded products	-	-	-
Builders' paper and roofing felt	x	-	-

x Regulations were proposed and promulgated for this pollutant or pollutant parameter.

* Regulations were proposed for this pollutant or pollutant parameter.

- no proposed regulation

Source: U.S., EPA, Off. of Water and Waste Mgmt., 1980.

[a] Five day biochemical oxygen demand, total suspended solids and pH are regulated for all categories, including the nonintegrated industry segment (not shown).

[b] BCT bleached kraft: paperboard, coarse and tissue bleached kraft.

[c] Includes fine bleached kraft and soda subcategories. The "best practicable control technology currently available" five day BOD effluent limitation for acetate grade production in the dissolving sulfite pulp subcategory was remanded to EPA.

TABLE 10-10: PULP MILL EFFLUENT[a]

Type of Mill	Untreated Effluent			After Treatment		
	BOD (lb)	Suspended Solids (lb)	Water (1000 gal)	BOD (lb)	Suspended Solids (lb)	Solid Residue (lb)
Kraft pulp						
-bleached	80	140	45	47	43	97
-unbleached	50	50	22	30	16	34
Groundwood pulp	22	25	10	13	8	17
Semichemical pulp	110	50	14	65	16	34
Sulfite pulp	600	62	48	354	19	43

Source: Hunt and Franklin, 1973.

[a] For one ton of product at average treatment levels in 1971.

TABLE 10-11: AVERAGE ANNUAL PULP AND PAPER DISCHARGE LEVELS (lbs/tons of pulp)

Type of Mill (Number of mills monitored)	BOD		Suspended Solids	
	Range	Average	Range	Average
Kraft pulp -bleached (9) (market bleached)	4-12	8.2	5-33	13.6
-unbleached (3) (dissolving kraft)	8-38	19.0	6-28	15.0
Roundwood pulp (2)	2-10	6.0	4-14	9.0
Semichemical pulp (10)	4-10	6.0	3-17	10.0

Source: U.S., EPA, ORD, 1980b, pp. 388-420.

within process types, a wide range of effluent levels occurs among individual mills, typically about a range of 3 to 5 fold among plants for the process types. These data have been used to suggest that the lower value in the range is the "best practicable control technology currently achievable" (U.S., EPA, Off. of Planning & Mgmt., 1980) and that many plants could achieve this lower level, but do not. Thus, although highly signficant reductions have been achieved for most pulp and paper mills, some plants have much lower effluent levels than others.

Some projections made by the EPA indicate large increases of gross BOD generation in the pulp and paper industry may occur between 1975 and 2000. In the High Growth Scenario projected by EPA's Strategic Environmental Assessment System (SEAS) model,[1] industry output increases by 4 percent per year, in constant dollars. This level of output results in an increase of gross BOD generation (but not necessarily discharge) from 1.7 million tons in 1975 to 3.4 million tons in 2000. Gross BOD generation in the Low Growth Scenario, in which industry output grows by 3 percent per year, would increase by one million tons.

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[1] SEAS models the economic and environmental effects of economic and population growth. In the High Growth Scenario, Gross National Product (GNP) grows by 3.5 percent per year, while population grows by 0.8 percent per year. In the Low Growth Scenario, GNP grows at an annual rate of 2.6 percent, while population grows at 0.6 percent per year (U.S., EPA, ORD, 1980a). Because of limitation in economic and technical assumptions, SEAS projections should be interpreted cautiously, and they are intended here to indicate a potential range of projections and their possible implications.

Although SEAS projections indicate large increases in gross BOD generation by the pulp and paper industry, net discharges are projected to drop considerably due to assumed improvements in wastewater treatment. In 1975, although half of BOD generation was removed before discharge, nearly three-quarters of a million tons of BOD were released to the environment. If the CWA goals are achieved, net discharges could decrease to as low as 250 thousand tons by 2000 according to the SEAS assumptions.

The pulp and paper industry accounted for about 4 percent (2,700 thousand tons) gross generation of suspended solids by point sources in 1975 (U.S., EPA, ORD, 1980a). Net discharges by the industry represented 19 percent (1,100 thousand tons) of all point source net discharges, however. According to SEAS projections, gross generation is expected to increase to 5,700 thousand tons in the high growth scenario by 2000, but net discharges would decrease to less than 20 percent of 1975 levels. This level of decrease, however, assumes achievement of CWA goals.

The enhancement in wastewater treatment for pulp and paper mills has resulted in significant improvement in streams adjacent to many of these facilities. For example, for years Bogue Lusa Creek, a tributary of the Pearl River in Louisiana was heavily polluted by a paper mill's chemical and wood fiber discharges. Extensive fish kills occurred, sport fish disappeared, and the Pearl River's water quality was seriously degraded for some 25 to 30 miles downstream from the confluence of Bogue Lusa Creek (U.S., EPA, Off. of Planning & Mgmt., 1980). In 1964, the company installed a primary treatment plant. The mill's BOD load, which had averaged 76,000 pounds a day, dropped to 54,000 pounds a day. The mill also installed a system to add oxygen to the water during periods of low flow in the summer and fall.

In 1972, a secondary treatment plant provided approximately 85 percent removal of BOD for some 25 to 35 million gallons a day. The mill's outfall was relocated to discharge directly into the much larger Pearl River. The mill now releases a maximum of 20,000 pounds a day of BOD.

The waters of the creek and the river have apparently been restored to levels close to their former quality. Large masses of partially decomposed wastes no longer float down the creek and the river, and the Pearl River's water quality has shown improvement for 20 to 30 miles downstream. Bogue Lusa Creek, which until recently was totally devoid of any aquatic life, now supports a sizeable population of fish (U.S., EPA, Off. of Planning & Mgmt., 1980).

As another example, in 1941 the St. Regis Paper Company built a pulp and paper mill in Escambia County, Florida. The mill's wastes were partially treated and then discharged into Eleven Mile Creek, which flows about 12 miles southwest to the upper end of Perdido Bay. Over the years, discharges into Eleven Mile Creek increased to about 29 million gallons of partially treated wastes each day. Discharges from the mill included 42,500 pounds of BOD wastes, 48,000 pounds of organic carbon, and 17,000 pounds of total suspended solids each day. The water was discolored, dissolved oxygen was very low, and swimming was impossible. In 1969, St. Regis Paper Company agreed to clean up its discharges, and it has done so steadily--with the aid of an EPA pilot plant grant. As a result, Florida now classifies its half of the bay and Eleven Mile Creek as suitable for swimming and for fish and wildlife preservation. Alabama has also classified its portion of the bay as suitable for these same uses and for shellfish harvesting as well (U.S., EPA, Off. of Planning & Mgmt., 1980). Additional descriptions of water quality concerns from these and related industrial developments are discussed in chapters 12 and 14.

10.5.3 Air Emissions

Air quality may be affected by increased carbon monoxide emissions by the paper and pulp industry. In Region 4, carbon monoxide emissions from the pulp and paper industry in the year 2000 are projected to increase between 100 and 150 percent over 1975 levels. Emissions in Region 6 are projected to triple by 2000, and represent 8 percent of regional carbon monoxide (U.S., EPA, ORD, 1980b).

Local problems may be created by strong odors of hydrogen sulfide and organic sulfur compounds.[1] Kraft pulp mills can create a community nuisance since total control of the odorous compounds and the particulate material is not yet possible. However, the frequency of nuisance complaints is apparently less now than ten or fifteen years ago, as improvements in the control of sulfur compound emissions are being achieved. Air quality regulatory issues and any potential requirements to reduce emission levels are a significant uncertainty for the pulp and paper industry. Air quality standards for some mills are difficult to achieve and present technical and financial problems (U.S., Dept. of Commerce, Bur. of Census, 1980b).

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[1] Organic sulfur compounds include mercaptans and some sulfides such as methyl sulfide and dimethyl disulfide.

10.5.4 Hazardous and Toxic Effluents

At the present time by-products and effluents from the pulp and paper industry are not classified as hazardous wastes (see Chapter 15). There is apprehension in the industry that classification of pulp mill process water as hazardous waste, for example, may require that many wastewater treatment ponds be lined with impervious material, which would require significant new expenditures (U.S., Dept. of Commerce, Bur. of Census, 1980b).

The levels of toxic effluents generated and released in pulp manufacture largely depend on the process. In the kraft process, levels of toxic effluents depend on the efficiency of pulp washing and frequency of spills. The volume of toxic effluents generally is less of a problem in the sulfite process, since many compounds are decomposed during the digestion phase. Although data concerning toxic effluents from the groundwood process are limited since few chemicals are used, effluents are probably lower than for the kraft or sulfite processes (Hutchins, 1979).

The EPA recently concluded a study of the need for regulations controlling potentially toxic effluents in pulp and paper mills. As shown in Table 10-12, the sulfite pulping process in the integrated segment and the deink and paper from wastepaper processes in the secondary fibers segment generate a wide range of potentially toxic pollutant chemicals (U.S., EPA, Off. of Water and Waste Mgmt., 1980). Table 10-12 shows only those potential toxic effluents with concentrations above or equal to specific treatability levels in either raw wastewater or net discharges (U.S., EPA, Off. of Water and Waste Mgmt., 1980). In general, these appear in amounts judged too small to be controlled (Natural Resources Defense Council, Inc. v. Train, 1976). Only three toxic effluents (trichlorophenol, chloroform, and pentachlorophenol) have been recommended to be regulated. Zinc is also currently regulated and has resulted in the reduction in use of zinc based additives (U.S., EPA, Off. of Water and Waste Mgmt., 1980).

10.6 SUMMARY

The pulp and paper industry is heavily concentrated within the study area and is projected to expand significantly in the future. The nationwide and worldwide marketing flexibility derived from being competitive as a low-cost producer may enable the industry to increase total shipments, and maintain a real growth at least commensurate with GNP.

The pulp and paper industry now withdraws large quantities of water, and is expected to increase consumption significantly in the future. The pulp and paper industry has made significant

TABLE 10-12: TOXIC POLLUTANTS OF THE PULP AND PAPER INDUSTRY

	Integrated				Secondary Fibers			
Toxic Pollutant	Kraft	Groundwood	Semichemical	Sulfite	Paper From Waste Paper	Deinking	Tissue From Waste Paper	Builders Paper and Roofing Felt
Benzene				X				
1,1,1 Trichloroethane				X				
Trichlorophenol[a]	X			X	X	X		
Chloroform[a]	X			X		X		
2 Chlorophenol				X				
2,4-Dichlorophenol				X				
Ethylbenzene					X			
Bromoform					X			
Napthalene				X		X		
Pentachlorophenol[a]	X	X		X	X	X		X
Phenol	X	X	X	X	X	X	X	X
Butyl Benzyl Phthalate	X		X		X	X		X
Di-N-Butyl Phthalate	X				X			X
Diethyl Phthalate					X		X	X
Tetrachloroethylene				X	X	X		
Toluene	X	X		X	X	X		
Trichloroethylene						X		
PCB 1242						X		
PCB 1254	X					X		
PCB 1248					X			X
PCB 1260						X		
Cyanide						X		X
Lead					X	X		X
Zinc[b]		X			X		X	X

Source: U.S., EPA, Off. of Water and Waste Mgmt., 1980.

[a] Proposed to be regulated.

[b] Currently regulated.

pollution control outlays and reduced levels of pollutant discharges significantly during the past decade. Nevertheless, the industry still faces a number of uncertainties, including the following:

(1) There are wide ranges in effluent levels from existing plants;

(2) Hazardous waste control requirements are not yet known; and

(3) New air and water quality standards may impose further technical and financial problems in some mills in the coming years.

The costs of environmental regulations for specific industry segments are obscured in the overall industry figures. However, the pulp mills, which supply the raw materials for further manufacture or for market shipment, undoubtedly generate most of the water quality, effluent disposal, air quality, and hazardous chemicals disposal problems within the industry. Locally, major environmental clean up "success" stories have accompanied pollution control improvements in the industry during the past decade. However, some plants are still accountable for major releases of biochemical oxygen demand, suspended solids, and air emissions that reduce local environmental quality in many southern localities.

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CHAPTER 11

AIR QUALITY

HIGHLIGHTS

- Status and Trends

1. Air quality throughout the Southeast and the Southwest is generally good and is expected to remain so in the future, even with continuing growth and development. The lack of Class I areas in the Southeast, the relatively low base of emissions levels in the Southwest, and the increasing use of innovative regulatory approaches should provide the flexibility needed by industry for location and expansion.

2. The Sunbelt states contributed approximately one-third of the U.S. emissions reported in 1978 for particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. Region 4 contributed about 22 percent of the nation's sulfur oxide emissions compared to 9 percent in Region 6. About 22 percent of the nation's nitrogen oxide emissions came from Region 6, primarily from Texas.

3. Mobile source emissions continue to be a major source of air pollution in the larger cities in the Sunbelt, especially Houston, Dallas, the Piedmont area of North Carolina and South Carolina near Charlotte and the Miami-Ft. Lauderdale and Tampa-St. Petersburg areas in Florida.

- Geographic Areas

4. The air quality of the Gulf Coast area of Texas may be subject to multiple and cumulative impacts from rapid population and industrial growth as well as energy developments. Projected increases in sulfur oxides, nitrogen oxides, particulates, and volatile organic compounds are attributed to current and anticipated increases in chemical production, multiple energy developments, some switching to coal-fired industrial combustion, and increasing mobile source emissions throughout the area.

5. Kentucky and Tennessee continue to have problems with sulfur dioxide emissions, especially in the Ohio River Basin and near the large coal-fired power plants for TVA--areas expected to maintain or increase power production levels in the future.

6. Ozone continues to be a problem in major cities throughout the Sunbelt, including Memphis, Tennessee; Mobile, Alabama; Albuquerque, New Mexico; El Paso, Texas; and Charlotte, North Carolina. Carbon monoxide levels have decreased in Louisville, Kentucky; Charlotte, North Carolina; and Nashville, Tennessee.

- Key Problems and Issues

7. Acid precipitation is of increasing concern in the South. Kentucky, Tennessee, Florida, and Texas contribute a large share of sulfur and nitrogen oxides believed to be precursors to acid rain. Parts of the Southwest and much of the Southeast, particularly central Alabama and Georgia, eastern Tennessee, and western North Carolina have soil conditions suggesting sensitivity to the effects of acid precipitation.

CHAPTER 11

AIR QUALITY

11.1 INTRODUCTION

Since the Clean Air Act (CAA) was passed over a decade ago, significant improvements in overall air quality have been made both across the nation and in the 13-state study area. For example, between 1973 and 1978, average annual concentrations of suspended particulates decreased by 7 percent nationally, sulfur dioxide (SO_2) by 20 percent, and carbon monoxide (CO) by 33 percent (U.S., NCAQ, 1981). In the southern regions, cities like Birmingham have shown dramatic improvement in air quality. Other cities, such as Louisville and Houston, with more intractable problems have begun to take advantage of new regulatory approaches such as the emission offset banking program.

As discussed in chapters 3 and 4, the Sunbelt is experiencing rapid growth and change from an increasing population, urbanization, industrialization, and energy development. While growth and development are creating economic benefits for the regions, they also have potentially negative implications for local and regional efforts to maintain or improve air quality. In addition, available information on toxic pollutants and the extent of wet and dry acid deposition suggests that a continuing effort will be required to provide room for economic growth in the region while maintaining air quality.

The following section (11.2) provides a brief overview of the regulatory system for air quality, the meteorological conditions affecting air quality in the study area, and the status of criteria and noncriteria pollution. Section 11.3 discusses how changes throughout the Sunbelt, such as urbanization, energy development and production, and industrial growth are likely to affect air quality concerns in the future.

11.2 EXISTING CONDITIONS

11.2.1 The Regulatory System

Major regulatory mechanisms for protecting air quality are shown in Table 11-1. Although most of these regulations are

TABLE 11-1: MAJOR REGULATORY MECHANISMS FOR AIR POLLUTION CONTROL

Regulatory Mechanism	Legislative Source of Mechanism	Scope: Regulates Emissions or Ambient Air Quality	Pollutants Regulated	Sources Affected	Summary Description of Regulation
National Ambient Air Quality Standards (NAAQS) and State Implementation Plan (SIP)	1970 CAA Amendments (P.L. 91-604)	Emissions and ambient air	All criteria pollutants	Stationary and mobile	For existing (pre-1971) industrial and electric utility facilities, sets limits on emissions as part of a statewide plan to reduce ambient concentrations of criteria pollutants.
New Source Performance Standards (NSPS)	1970 CAA Amendments	Emissions	All criteria pollutants	Stationary	Requires new facilities in selected industries to meet national emission standards for criteria pollutants.
Revised NSPS	1977 CAA Amendments (P.L. 95-95)	Emissions	All criteria pollutants	Stationary	Provides new and stricter emission standards for criteria pollutants reflecting the degree of control that can be achieved by best available control technologies (BACT).
Mobile Source Emission Standards	1970 CAA Amendments	Emissions	Nitrogen oxides, hydrocarbons, carbon monoxide, photochemical oxidants	Mobile	Requires automobile and truck manufacturers to produce vehicles meeting standards that are made more stringent over time.

(continued)

TABLE 11-1: (continued)

Regulatory Mechanism	Legislative Source of Mechanism	Scope: Regulates Emissions or Ambient Air Quality	Pollutants Regulated	Sources Affected	Summary Description of Regulation
Offset Requirements	1977 CAA Amendments	Emissions	All criteria pollutants	Stationary and mobile	In areas violating primary and secondary NAAQS, requires sources to identify and implement methods to more than "off-set" emission increases by reducing emissions from sources already in the area.
Prevention of Significant Deterioration (PSD) Requirements	1977 CAA Amendments	Ambient air	Particulates, sulfur dioxide	Stationary and mobile	In areas that meet NAAQS, strictly regulates increases in ambient pollution levels in order to prevent any significant deterioration of air quality.
National Emission Standards for Hazardous Air Pollutants	1970 CAA Amendments	Emissions	Asbestos, beryllium, mercury, vinyl chloride, and radionuclides	Stationary and mobile	Provides emission standards for hazardous air pollutants that are not regulated by ambient air quality standards.

Source: Adapted from U.S., EPA, ORD, 1980a.

stated in terms of abatement of emissions at their sources, in combination they are designed to achieve congressionally mandated standards for ambient air quality designed to protect public health (primary standards) and welfare (secondary standards). Criteria have been established to limit the permissible ambient concentrations of seven pollutants--particulates (TSP), sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons (HC), CO, photochemical oxidants (measured as ozone), and lead. The 1977 CAA Amendments require periodic review of these standards, including analyses of whether other pollutants (e.g., fine particulates, sulfates) need to be controlled.

The CAA has been scheduled for reconsideration by Congress in 1981-82 as part of the periodic reauthorization process. Although broad support continues to exist nationally for the goals of the CAA (see Chapter 5), Congress may make major changes in specific sections of the statute. Rather than anticipating these changes, the discussion on problems and issues in this chapter will be based on the existing statute as amended in 1970 and 1977.

11.2.2 Meteorology

Large-scale meteorological conditions as well as local air dispersion factors such as windspeed, wind direction, or cloud cover can directly affect both local and regional air quality. The climate of the Sunbelt is influenced by the large continental area of the region and the tropical and subtropical Gulf and Atlantic Ocean areas. Typically, ventilation in the area is good with predominant southwesterly winds. However, dramatic changes in weather patterns are common, especially in the spring and fall months as cold and warm fronts move in and out of the region. During these periods, stagnant air pollution episodes are at a minimum.

During winter and summer months the movement of fronts is slower and high pressure can settle over all or parts of the southern regions, especially the Southeast, causing air stagnation with an enhanced probability of air pollution. Since pressure fronts are not as frequent during these months, the slower moving air also circulates pollutants locally among industrial centers; thus, atmospheric loadings are very different from the qualities of the original tropical or subartic air. Atmospheric loadings in Oklahoma, for example, can originate from industrial centers in Texas when southerly flow predominates. But with the passage of cold fronts, southern areas may receive pollutants from the Ohio River Basin. Large-scale counter-clockwise air circulation around high pressure zones can lead to continued accumulation of air pollutants in the South as air from the Ohio River Basin circles through the southwestern states, over to the southern states and back up toward the basin. In most cases, however, these circulation patterns do not persist, so that local meteorological conditions and atmospheric loadings tend to be a more important factor for air quality.

Figure 11-1 indicates regions in the study area which are particularly susceptible to air pollution problems by showing the total forecast days of high meteorological potential for air pollution in a five-year period. Much of Region 4 is especially susceptible to these episodes, particularly the Appalachian and Piedmont areas in Kentucky, North Carolina, South Carolina, Georgia, Alabama, and Tennessee. Northern Georgia and Alabama, eastern Kentucky and Tennessee and western North Carolina have 30 or more such forecast days in a five-year period. Metropolitan areas subject to episodes of high air stagnation caused by low winds and mixing heights include New Orleans, Louisiana; Birmingham, Alabama; Atlanta, Georgia; Knoxville and Nashville, Tennessee; Little Rock, Arkansas; Amarillo and El Paso, Texas.

Meteorological conditions generally affect the extent to which air quality interacts with other media (e.g., land and water) to create potential environmental problems. For example, the amount of moisture and the form which it takes (e.g., dew, fog, rain, snow, etc.) in a particular area can determine the extent to which air pollutants are deposited on soils and bodies of water in the area rather than being dispersed or transported to another area. In addition to acid deposition, other problems found to be associated with long-range pollutant transport include the deterioration of visibility throughout a region, the transport of ozone and ozone precursors between nearby areas, and growing interstate air pollution (U.S., NCAQ, 1981).

11.2.3 Criteria Pollutants

A. Major Sources and Emission Levels

The National Ambient Air Quality Standards (NAAQS) were established to protect human health and welfare from the most pervasive pollutants. To date, standards have been established for seven of these "criteria" pollutants, as identified in the section on the regulatory system. Under the Congressional mandate in the CAA, standards for criteria pollutants are based on a threshold concept--i.e., a level of pollution exists below which there are no adverse effects. In addition, the standards assume a "margin of safety," so that even those groups believed to be the most susceptible to the health effects of the particular pollutant will not experience adverse effects from pollution levels just below the standards (Landsberg et al., 1979, p. 344). However, the lack of sufficient knowledge about such effects has made these standards controversial.

One of EPA's data systems related to air quality is the National Emissions Data System (NEDS) (U.S., EPA, Off. of Air

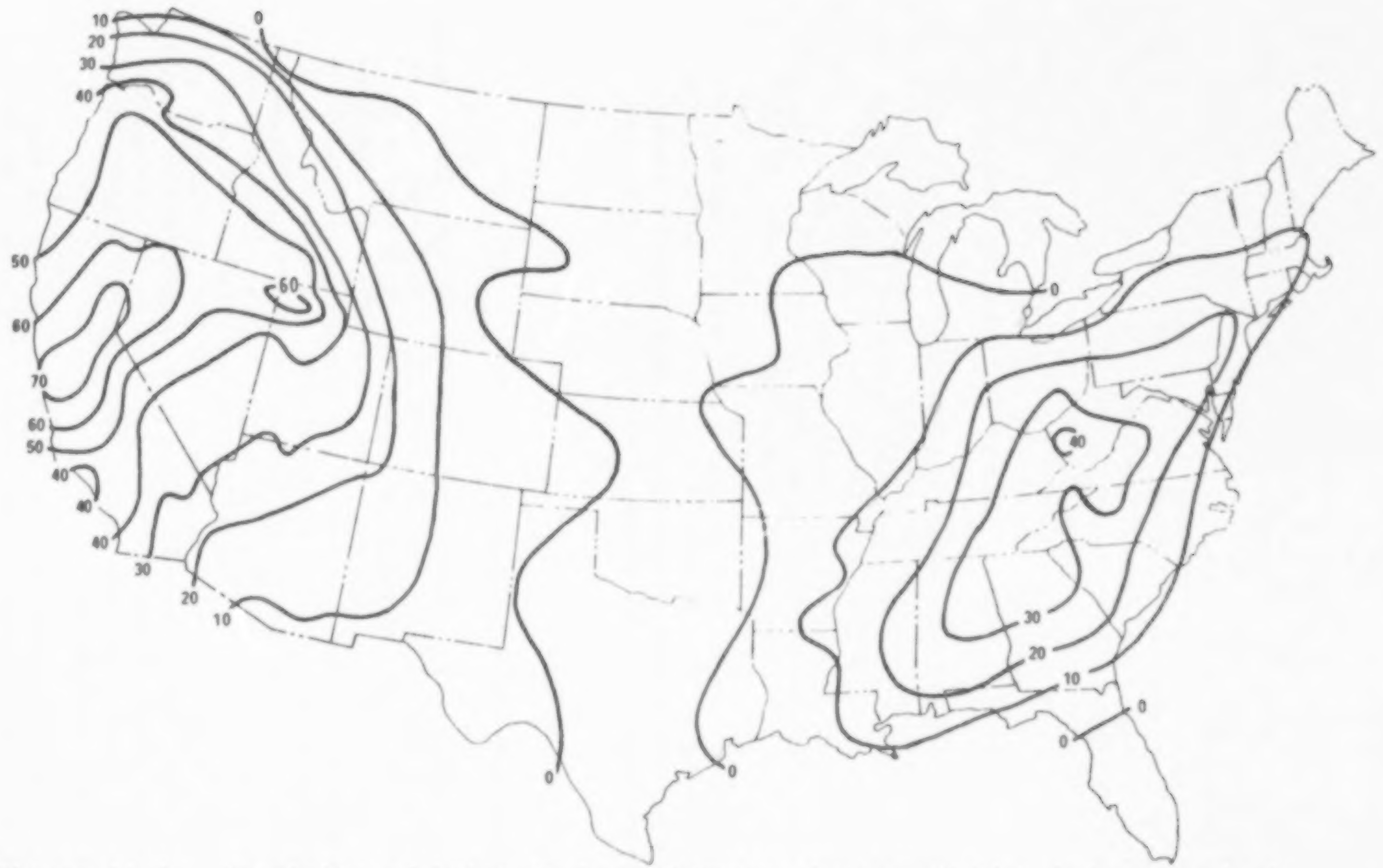

Figure 11-1: Isopleths of Total Number of Forecast-Days of High Meteorological Potential for Air Pollution in a 5-year Period. (Data based on forecasts issued since August 1, 1960 and October 1, 1963 for eastern and western parts of the United States, respectively, through April 3, 1970)

Source: Holzworth, 1972.

Quality Planning and Standards, 1980a), comprised of emissions estimates for individual point and area sources. Table 11-2, based on the NEDS data, shows the percentage which each state in regions 4 and 6 contributes to the regional and national total emissions levels for five pollutants: TSP, SO_x, NO_x, HC, and CO. The Sunbelt states contribute approximately one-third of the U.S. total of all five pollutants. The two regions contribute approximately equal amounts of NO_x, HC, and CO to the national total. However, the relative contribution of states within the Southeast and Southwest can vary widely. For example, as might be expected both from land area and industrial development, Texas contributed over one-half of the total emissions for each of the pollutants in Region 6. In Region 4, emissions were more even. In only two instances did a state exceed a 20 percent share of the regional emissions: Kentucky contributed 25 percent of the SO_x emissions in 1978 and Florida contributed 24 percent of the CO emissions for 1978.

In contrast to the relatively even regional contributions for NO_x, HC, and CO, Region 6 contributed twice the proportion (25 percent) to the national total TSP emission levels that Region 4 (12 percent) contributed in 1978. Texas and New Mexico together were responsible for over 75 percent of Region 6's TSP emissions, primarily because of the high levels of localized dust from unpaved roads, agricultural activities, and fugitive dust. Within Region 4, TSP emissions were more evenly distributed among the states, with Florida contributing the largest state share (17 percent).

The regional roles in generating SO_x emissions are reversed, with Region 4 contributing a two and one-half times greater share to the national total than did Region 6. In Region 4, Kentucky and Tennessee contributed 24 percent and 19 percent, respectively, of the regional total for SO_x emissions, primarily as a result of coal-fired electric generation. In Region 6, Texas contributed the largest share (58 percent) of regional SO_x emissions. However, the sources of those emissions were more diverse than they were for most of the states in Region 4.

Major sources[1] of emissions for five pollutants within each of the states have been summarized for both the Southeast and the Southwest. In the southeastern states (see Table 11-3), TSP was primarily attributable to unpaved roads and land vehicles. This is not the case for Alabama, where electric generation contributed 28 percent of that state's total, and Kentucky where mineral products (stone, clay, and glass) contributed 28 percent to the state's total.

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[1] These tables identify all sources which contribute 10 percent or more to the states' total emission tons per year for a given pollutant. Emissions data for lead are not yet available.

TABLE 11-2: STATE CONTRIBUTION TO REGIONAL EMISSIONS OF CRITERIA POLLUTANTS, 1978

	Pollutants				
	TSP	SO_x	NO_x	HC	CO
Region/State	(percent of regional total)				
Region 4					
Alabama	13%	15%	13%	12%	12%
Florida	17	14	19	20	24
Georgia	13	10	12	13	15
Kentucky	11	24	15	10	9
Mississippi	13	4	7	7	7
North Carolina	13	9	14	16	14
South Carolina	7	5	7	9	8
Tennessee	13	19	15	13	12
Total (tpy)	5,731,439	6,911,677	4,107,793	4,737,254	19,790,082
(% of U.S. total)	(12%)	(22%)	(17%)	(16%)	(17%)
Region 6					
Arkansas	8%	6%	5%	6%	8%
Louisiana	5	14	25	18	17
New Mexico	24	19	6	4	6
Oklahoma	11	3	9	9	12
Texas	52	58	56	63	57
Total (tpy)	11,551,547	2,862,952	5,360,245	5,206,846	17,383,198
(% of U.S. total)	(25%)	(9%)	(22%)	(18%)	(15%)
Regions 4 and 6					
Total	17,282,986	9,774,629	9,468,038	9,944,100	37,173,280
(% of U.S. total)	(37%)	(30%)	(39%)	(34%)	(32%)
Total U.S.	46,855,182	32,141,311	24,021,172	29,445,356	116,301,567

Source: Calculated from U.S., EPA, Off. of Air Quality Planning and Standards, 1980a.

TABLE 11-3: MAJOR SOURCES[a] OF CRITERIA POLLUTANTS FOR STATES IN REGION 4, 1978

State		Pollutant Source (% of state total)				
		TSP	SO_x	NO_x	HC	CO
Alabama	Total	718,577 tpy	1,047,487 tpy	526,074 tpy	522,415 tpy	2,425,847 tpy
		Electric generation (28%) Unpaved roads (28%) Land vehicles (15%) Industrial fuel combustion (12%)	Electric generation (70%) Industrial fuel combustion (15%) Industrial processes (11%)	Electric generation (37%) Land vehicles (37%)	Land vehicles (40%) Solvent evaporation loss (23%) Industrial processes (13%)	Land vehicles (70%) Forest wildfires and managed burning (20%) Industrial processes (11%)
Florida	Total	975,710 tpy	963,724 tpy	764,131 tpy	938,067 tpy	4,807,813 tpy
		Unpaved roads (46%) Land vehicles (30%)	Electric generation (70%) Industrial processes (12%) Industrial fuel combustion (10%)	Land vehicles (44%) Electric generation (38%)	Land vehicles (53%) Solvent evaporation loss (22%)	Land vehicles (85%)
Georgia	Total	743,240 tpy	696,157 tpy	477,671 tpy	628,971 tpy	2,899,085 tpy
		Unpaved roads (59%) Land vehicles (21%)	Electric generation (79%) Industrial fuel combustion (12%)	Land vehicles (55%) Electric generation (28%)	Land vehicles (49%) Solvent evaporation loss (30%)	Land vehicles (82%)

(continued)

TABLE 11-3: (continued)

State		Pollutant Source (% of state total)				
		TSP	SO_x	NO_x	HC	CO
Kentucky	Total	641,066 tpy	1,630,831 tpy	608,272 tpy	485,273 tpy	1,695,555 tpy
		Mineral products (28%)	Electric generation (94%)	Electric generation (57%)	Land vehicles (40%)	Land vehicles (87%)
		Unpaved roads (26%)		Land vehicles (30%)	Solvent evaporation loss (17%)	
		Electric generation (15%)			Organic solvent evaporation (11%)	
		Land vehicles (14%)				
Mississippi	Total	734,500 tpy	310,256 tpy	273,632 tpy	351,466 tpy	1,301,368 tpy
		Unpaved roads (67%)	Electric generation (69%)	Land vehicles (42%)	Land vehicles (34%)	Land vehicles (70%)
		Industrial processes (14%)	Industrial processes (16%)	Electric generation (26%)	Solvent evaporation loss (22%)	Forest wildfires, managed fires, agricultural burning (12%)
				Industrial fuel combustion (16%)	Industrial processes (20%)	
North Carolina	Total	740,582 tpy	649,516 tpy	556,501 tpy	758,141 tpy	2,801,464 tpy
		Unpaved roads (51%)	Electric generation (67%)	Land vehicles (50%)	Land vehicles (42%)	Land vehicles (86%)
		Land vehicles (19%)	Industrial fuel combustion (20%)	Electric generation (35%)	Solvent evaporation loss (29%)	
		Electric generation (13%)			Industrial processes (6%)	
		Industrial processes (10%)				

(continued)

TABLE 11-3: (continued)

State		Pollutant Source (% of state total)				
		TSP	SO_x	NO_x	HC	CO
South Carolina	Total	410,520 tpy	325,269 tpy	300,348 tpy	404,281 tpy	1,530,517 tpy
		Unpaved roads (47%)	Electric generation (62%)	Land vehicles (45%)	Land vehicles (40%)	Land vehicles (79%)
		Land vehicles (18%)	Industrial fuel combustion (26%)	Electric generation (33%)	Solvent evaporation loss (25%)	
		Industrial processes (11%)		Industrial fuel combustion (15%)	Industrial processes (16%)	
Tennessee	Total	767,244 tpy	1,288,427 tpy	601,164 tpy	618,640 tpy	2,328,433 tpy
		Unpaved roads (56%)	Electric generation (78%)	Electric generation (38%)	Land vehicles (42%)	Land vehicles (85%)
		Land vehicles (17%)	Industrial fuel combustion (15%)	Land vehicles (40%)	Solvent evaporation loss (21%)	
					Chemical manufacturing (10%)	

tpy = tons per year

Source: Calculated from U.S., EPA, Off. of Air Quality Planning and Standards, 1980a.

[a] A major source was defined to be any which contributed 10 percent or more to the state emissions level for any one of the five criteria pollutants.

Electric generation (e.g., coal-fired power plants) contributed 62 percent or more of the SO_x emissions for each state in the Southeast. As a region, the Southeast contributed 22 percent to the national total. Of Kentucky's high regional share of 24 percent, 94 percent was attributed to electric generation, while 78 percent of Tennessee's share was attributed to this source.

Emissions from land vehicles and electric generation were typically the major sources for NO_x emissions in all states in Region 4, while land vehicles and organic solvent evaporation were the major sources for HC emissions in the region. Land vehicles were the major source of CO with heavily populated and urbanized Florida contributing the largest share in the region.

As mentioned earlier, the southwestern states were a major source of TSP in 1978 (see Table 11-4); however, in every state but Louisiana, 80 percent or more of these emissions were attributed to unpaved roads. In Louisiana, 44 percent were attributed to unpaved roads, while industrial processes were attributed with 22 percent and land vehicles with 18 percent.

Southwestern states contributed a smaller share of SO_x emissions than states in the Southeast, yet these emissions were generated by a wider variety of sources. While electric generation was still an important source in every state in Region 6, other sources such as industrial fuel combustion, petroleum industry, and primary metals were also important. In Texas, for example, which contributed at least three times more SO_x emissions to the regional total than did any other state, major sources included chemical manufacturing (23 percent), electric generation (21 percent), industrial fuel combustion (15 percent), petroleum industry (13 percent) and primary metals (11 percent). The major sources of NO_x emissions in Louisiana and Texas, which contributed the largest share in Region 6, were electric generation, industrial fuel combustion, and land vehicles. Similarly, these two states contributed a large regional share of HC, primarily from land vehicles, industrial fuel combustion, and the chemical and petroleum industries. As expected, land vehicles were the major source of CO emissions in all five states of Region 6.

Another perspective on emissions of criteria pollutants can be gained by examining emission levels within Air Quality Control Regions (AQCR's). As part of the effort to implement NAAQS, AQCR's were mandated by the 1970 CAA.[1] AQCR's (see Appendix 11A) are frequently used to indicate areas where emissions are high

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[1] AQCR's were designated by EPA after consultation with states in March of 1971 (Dolgin and Guilbert 1974, p. 1067). See Appendix 11A for a map of AQCR's.

TABLE 11-4: MAJOR SOURCES[a] OF CRITERIA POLLUTANTS FOR STATES IN REGION 6, 1978

State		Pollutant Source (% of state total)				
		TSP	SO_x	NO_x	HC	CO
Arkansas	Total	963,136 tpy	158,227 tpy	245,694 tpy	294,508 tpy	1,349,446 tpy
		Unpaved roads (80%)	Electric generation (38%) Industrial fuel combustion (33%) Industrial processes (21%)	Land vehicles (51%) Electric generation (22%) Industrial processes (19%)	Land vehicles (45%) Solvent evaporation loss (30%)	Land vehicles (75%)
Louisiana	Total	608,188 tpy	396,089 tpy	1,346,496 tpy	947,667 tpy	2,949,623 tpy
		Unpaved roads (44%) Industrial processes (22%) Land vehicles (18%)	Petroleum Industry (30%) Industrial fuel combustion (20%) Electric generation (17%)	Industrial fuel combustion (60%) Electric generation (14%) Land vehicles (13%)	Industrial fuel combustion (25%) Land vehicles (23%) Chemical Manufacturing (19%)	Land vehicles (57%) Chemical manufacturing (25%)
New Mexico	Total	2,803,306 tpy	557,216 tpy	311,936 tpy	214,363 tpy	975,742 tpy
		Unpaved roads (95%)	Primary metals (44%) Electric generation (23%) Petroleum Industry (16%)	Electric generation (39%) Industrial fuel combustion (33%) Land vehicles (22%)	Land vehicles (47%) Industrial fuel combustion (17%) Petroleum storage and transport (10%)	Land vehicles (87%)

(continued)

TABLE 11-4: (Continued)

State		Pollutant Source (% of state total) TSP	SO$_x$	NO$_x$	HC	CO
Oklahoma	Total	1,215,256 tpy	98,440 tpy	462,173 tpy	486,705 tpy	2,113,462 tpy
		Unpaved roads (82%)	Petroleum industry (36%) Industrial fuel combustion (29%) Electric generation (15%) Land vehicles (11%)	Land vehicles (36%) Industrial fuel combustion (36%) Electric generation (25%)	Land vehicles (41%) Petroleum industry and transportation (17%) Solvent evaporation loss (15%) Industrial fuel combustion (14%)	Land vehicles (76%) Industrial processes (12%)
Texas	Total	5,961,661 tpy	1,652,980 tpy	2,993,946 tpy	3,263,603 tpy	9,994,925 tpy
		Unpaved roads (82%)	Chemical manufacturing (23%) Electric generation (21%) Industrial fuel combustion (15%) Petroleum industry (13%) Primary metals (11%)	Industrial fuel combustion (45%) Electric generation (22%) Land vehicles (22%)	Land vehicles (25%) Chemical manufacturing (17%) Petroleum storage and transport (11%) Solvent evaporation loss (11%)	Land vehicles (65%) Forest wildfires (13%) Chemical manufacturing (10%)

Source: Calculated from U.S., EPA, Off. of Air Quality Planning and Standards, 1980a.

[a] A major source was defined to be any which contributed 10% or more to the state emission level for any of the five criteria pollutants.

and, thus, where SIP's need to place emphasis. Figure 11-2 displays 1975 emissions by AQCR for five pollutants: TSP, SO_x, NO_x, HC, and CO (Pechan, 1977). The darkest areas of the map show areas with the highest emissions. Because AQCR's have different numbers of monitoring stations, this information does not mean that an entire shaded area has constant emissions; rather, these shadings simply suggest general areas in which relatively high emissions have been recorded.[1] These data must be interpreted cautiously since they are fairly old (1975) and displayed in a somewhat arbitrary way (see footnote 1). However, it is useful for indicating general areas of emissions. For example, for every pollutant, many AQCR's along the Gulf Coast record relatively high emissions compared to those for the other Sunbelt AQCR's; this typically includes about half of the Texas Coast, across Louisiana and Alabama, and into the Florida panhandle. Consistently high emissions are also found in the southern Appalachian region, including northern Alabama, and central and eastern Tennessee. Much of central and southeastern Florida records high emissions of SO_x, NO_x, HC, and CO.

More specific information is supplied by emission inventories, as shown for Region 4 in Table 11-5.[2] Emission inventories indicate total county emissions for criteria pollutants based on emissions listed on permit applications, voluntarily reported emissions, and estimates of area sources (U.S., EPA, Region 4, 1978). The counties shown in Table 11-5 are those for which emissions were in the highest of four categories.[3] Some states have problems with several pollutants: Florida, for example, has at least ten counties in the highest emission category for NO_x, HC, and CO. Similarly, Tennessee and Kentucky have several counties which rank high in emissions of at least three pollutants. Three of these counties have cities with over 700,000 people.

These data provide an indication of some of the worst counties in the study area in terms of emission sources. Six counties in Region 4 rank high on emissions for four pollutants: Jefferson County (Alabama), Polk County (Florida), Chatham County (Georgia), Jefferson County (Kentucky), Mecklenburg County (North

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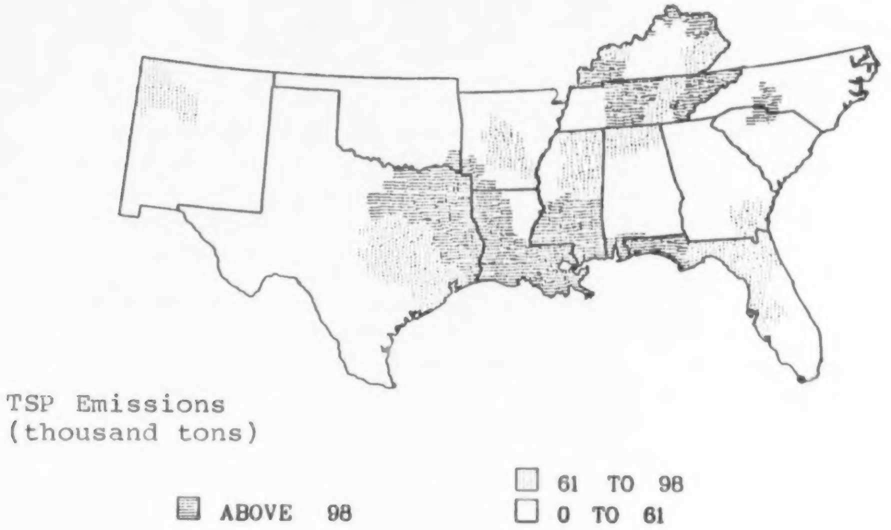
[1] Shading intervals for these maps were selected so that 70 percent of the land areas would remain unshaded, 15 percent would be shaded light, and 15 percent shaded dark (Pechan 1977, p. 46). Justification for this classification was not provided in the report.

[2] The emissions inventory from Region 6 had not been made available at the time that this report was prepared.

[3] For example, particulate emissions are categorized as: (1) less than 1,000 tpy; (2) 1,000 to 2,999 tpy; (3) 3,000 to 9,999 tpy; and (4) 10,000 or more tpy.



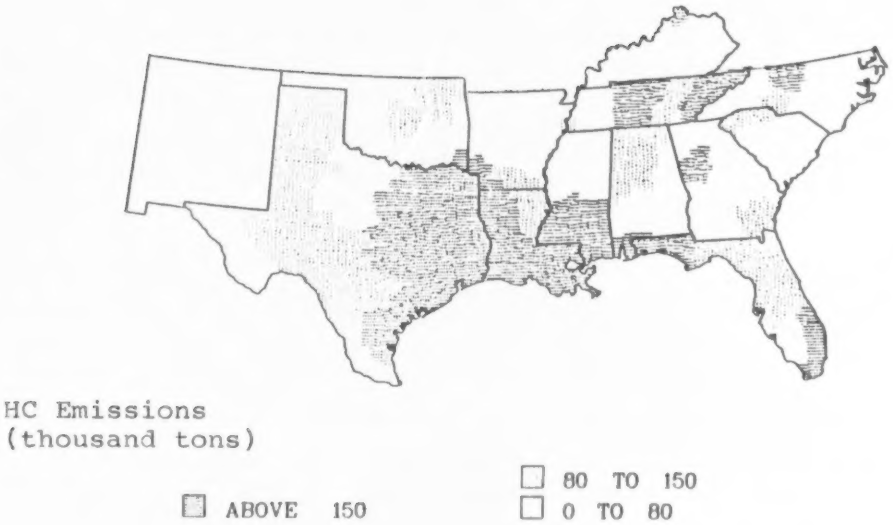
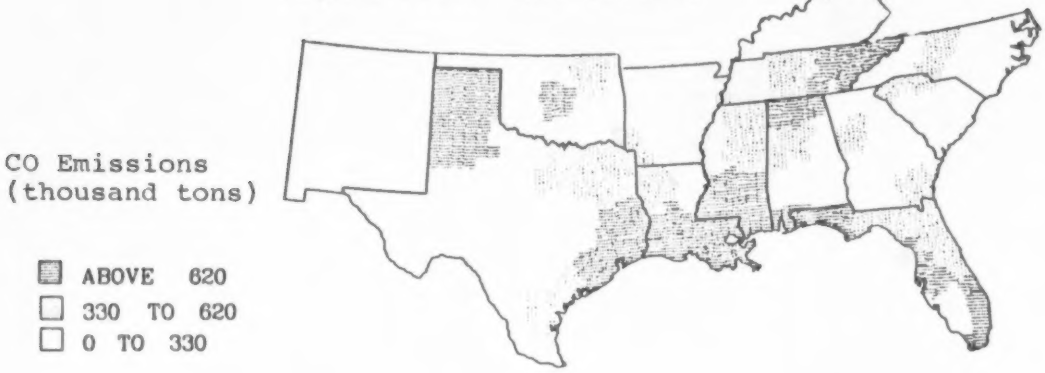
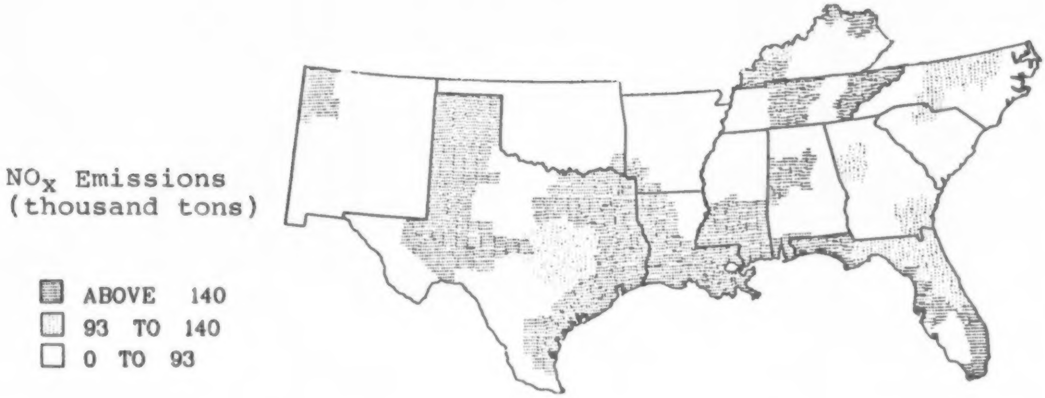


Figure 11-2: Emissions of Criteria Pollutants in 1975
(continued on next page)

Source: Pechan, 1977; data from the National Emissions Data System.

Figure 11-2: (continued)


CO Emissions
(thousand tons)


NO_x Emissions
(thousand tons)

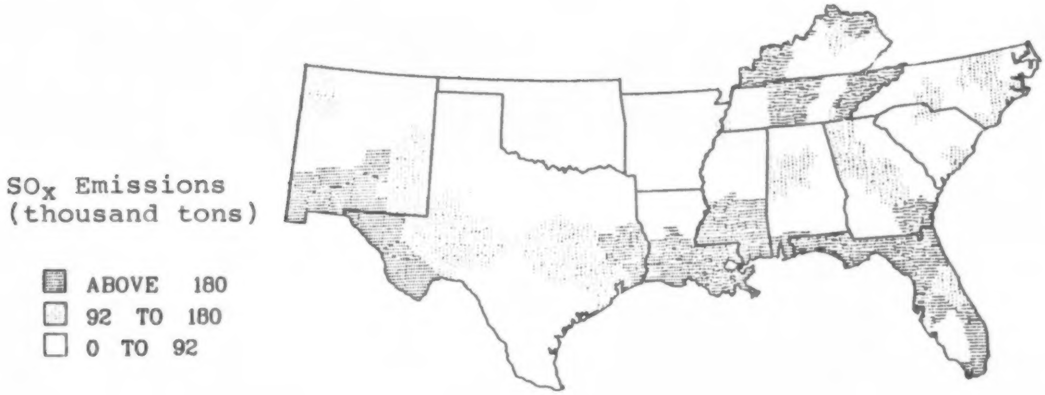

SO_x Emissions
(thousand tons)

TABLE 11-5: EMISSIONS INVENTORIES, REGION 4

	Counties with High Emissions (tpy)				
State	TSP (10M or more)	NO_x (10M or more)	HC (10M or more)	CO (100M or more)	SO_2 (100M or more)
Alabama	*Jefferson[a] Colbert Jackson Mobile Talledega	*Jefferson Mobile Morgan Walker Greene Jackson Shelby	*Jefferson Mobile Morgan	*Jefferson Mobile	Walker Colbert Jackson Shelby
Florida	*Dade Polk[b]	Bay Brevard *Broward Dade Duval Escambia *Hillsborough Indian River Lee Manatee Martin Nassau Orange Palm Beach *Pinellas Polk Volusia	Alachua Bay Brevard Broward Dade Duval Escambia *Hillsborough Okaloosa Orange Palm Beach *Pinellas Polk Sarasota Volusia	Broward[a] Dade Duval *Hillsborough Orange Palm Beach *Pinellas Polk Volusia Walton	Escambia

(continued)

TABLE 11-5: (continued)

State	Counties with High Emissions (tpy)				
	TSP (10M or more)	NO_x (10M or more)	HC (10M or more)	CO (100M or more)	SO_2 (100M or more)
Georgia	Bartow Chatham	Bartow Bibb Chatham Cobb Coweta DeKalb Early Floyd *Fulton Putnam	Chatham DeKalb *Fulton	Chatham DeKalb[1] *Fulton[1] Worth	Bartow Coweta Floyd Sumter
Kentucky	Boyd[a] Breathitt Harlan *Jefferson[a] Lawrence Letcher Livingston McCracken[a] Marshall[a] Mercer Muhlenberg[a] Pendleton Pike Pulaska	Boyd Daviess Hancock *Jefferson Lawrence McCracken Mercer Muhlenberg	Boyd Christian Fayette *Jefferson Marshall Meade Pendleton	*Jefferson[a]	McCracken[a] Muhlenberg[a]
Mississippi	Monroe	Hinds Warren	Hinds	--	Jones

(continued)

TABLE 11-5: (continued)

State	Counties with High Emissions (tpy)				
	TSP (10M or more)	NO_x (10M or more)	HC (10M or more)	CO 100M or more)	SO_2 (100M or more)
Tennessee	*Davidson[a] Hamblem Hamilton[a] Hawkins Humphreys Loudon Roane[a] *Shelby[a] Sullivan[a] Sumner[b]	Anderson Davidson Hamilton Hawkins Humphreys Knox Roane *Shelby Stewart Sullivan Sumner	Bradley Davidson Giles Hamilton Knox Sullivan Sumner	Davidson[a] Hamilton Knox[a] McMinn *Shelby[a]	Humphreys[a] Roane Stewart Sullivan Sumner

M = thousand

*Counties with cities with populations over 700,000.

Sources: From U.S., EPA, Region 4, 1978, pp. 25-27; Alabama, Air Pollution Control Commission, 1981; North Carolina, Dept. of Natural Resources and Community Development, 1981.

[a] Nonattainment for primary standard.

[b] Nonattainment for secondary standard.

Carolina), and Sumner County (Tennessee). With the exception of Chatham County, all of these counties are nonattainment areas for at least one pollutant. These counties may warrant special attention because large population centers are nearby, as is the case for Birmingham in Jefferson County (Alabama) and Savannah in Chatham County (Georgia), because of increasing concern about the interaction of pollutants (such as SO_x and fine particulates), or because of the increasing concern for identifying sources of pollutants which are transported long-range.

The ambient air quality standard for lead of 1.5 micrograms per cubic meter ($\mu g/m^3$) (quarterly average) was established in October 1978; however, monitoring stations are not required to track lead emissions until July 1982. The primary source of lead emissions has been automobiles--accounting for over 95 percent of approximately 190,000 tons[1] of lead emitted in 1975 in the U.S. (U.S., EPA, ORD, 1980a, pp. 128-29). This source should decrease dramatically over the next two decades due to regulation of lead content of fuels. Other primary emission sources are lead smelting, electric power plants, industrial combustion, petroleum refining, solid waste incineration, and gray iron production.

Although the CAA was passed by Congress to protect the public health from potentially harmful pollutants, the government is still faced with considerable uncertainty in trying to determine the specific pollutants and levels of pollutants which are likely to produce "adverse health effects"; indeed, a consensus does not exist even within the scientific and medical communities on what is meant by "adverse health effects." There is, nonetheless, persuasive evidence that air pollution can adversely affect health.

Health concerns with criteria pollution range from irritation of membranes to morbidity and mortality. Some criteria pollutants can cause direct health effects--for example, TSP and SO_2 can impede respiratory mechanisms, and lead is a highly toxic pollutant with impacts on blood heme formation, kidneys, and the nervous system. Criteria pollutants are also a concern because of indirect effects: oxidation products of nitrogen dioxide (NO_2) can create respiratory problems, ozone and HC can lead to eye and throat irritation, and sulfates can cause respiratory problems (U.S., NCAQ, 1981).

Clinical and epidemiological studies are continuing to provide information on the effects of varying exposure levels of criteria pollutants. Moreover, these studies are also suggesting new areas of concern. For example, fine particles (less than one micron in diameter) are now considered potentially more hazardous to human health than those coarser particulates currently regulated. This is because finer particles (1) lodge in the small airways and air sacs of the lung which are quite vulnerable to injury; (2) are more difficult for the body to clear out because they tend to locate in the small airways and air sacs; and (3) are most likely to penetrate the circulatory system, again, because of the anatomical characteristics of the small airways and air sacs (U.S., NCAQ, 1981, p. 74).

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[1] This figure was obtained by averaging the three estimates found on page 129 of the Environmental Outlook.

Fine particulates can absorb SO_2 and, perhaps, forms of sulfate (SO_4) such as sulfuric acid. When absorbed by fine particulates, the effects of SO_4 compounds may be increased because these particles tend to remain in the respiratory system for long periods (American Chemical Society, 1978). Studies have shown that this synergistic effect causes "increased death rates for persons over 50 years of age," when particulate concentrations are about 100 milligrams per cubic meter and when sulfate levels result in SO_4 precipitation rates above 30 milligrams per square centimeter per month (Greenfield, Attaway, and Tyler, 1975).[1]

This information suggests that regions with both high SO_x and high TSP concentrations are more likely to experience greater adverse health effects from the combined effects of SO_2 and TSP. In 1975, both Region 4 and Region 6 were relatively free of counties which violated both SO_2 and TSP standards; Region 4 had four such counties and Region 6 none (U.S., EPA, ORD, 1980a, p. 215). However, Region 6 is projected to have sharp increases in SO_x and moderate increases in TSP and, therefore, may be at risk for higher levels of respiratory illness related to SO_x and TSP interaction.

B. Nonattainment Areas

1. Counties

Attainment of NAAQS is a critical EPA concern since these standards are intended to protect human health (primary standards) and welfare (secondary standards). States are responsible for developing SIP's for meeting these standards. Table 11-6 identifies the percentage of counties in regions 4 and 6 which violated standards for TSP, SO_2 and CO, NO_2, and photochemical oxidants (O_x) in 1978 (U.S., CEQ, 1980).

In 1978 Region 4 had a large number of total counties in violation of standards, ranking second in this regard among the ten regions for both TSP and SO_x (U.S., EPA, ORD, 1980a). However,

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[1] Milligrams per square centimeter per month is the quantity that settles into a square centimeter plate in one month's time.

TABLE 11-6: FREQUENCY OF VIOLATIONS OF EPA CRITERIA POLLUTANT STANDARDS BY COUNTIES IN THE TEN FEDERAL REGIONS, 1978.

Federal Region (number of counties monitoring criteria pollutants)[a]	CO		O_x		NO_2		SO_2		TSP	
	% with NAAQS Violations	% >10 Violation Days	% with NAAQS Violations	% >10 Violation Days	% with NAAQS Violations	% >10 Violation Days	% with NAAQS Violations	% >10 Violation Days	% with NAAQS Violations	% >10 Violation Days
4 Southeast (298)	58	23	67	12	13	0	8	0	8	1
6 Southcentral (129)	28	11	96	35	8	0	1	0	24	3
1 New England (41)	73	55	76	29	0	0	7	10	10	0
2 New York-New Jersey (83)	55	21	81	31	9	0	5	0	11	2
3 Middle Atlantic (147)	43	8	79	47	21	4	4	1	12	1
5 Great Lakes (225)	64	28	79	34	18	0	14	3	27	5
7 Central (61)	62	31	46	31	40	20	6	0	32	4
8 Mountain (130)	82	53	50	10	5	0	9	7	29	2
9 West (70)	50	19	60	30	22	3	13	7	38	7
10 Northwest (71)	89	67	50	0	0	0	14	0	40	1

Source: U.S., CEQ, 1980.

[a] Counties monitoring data on at least one criteria pollutant.

since Region 4 had more counties than any other region, the percent of its counties in violation is relatively small compared to other regions. In contrast to every other region except the West, the Southeast had more rural than urban counties in violation of TSP standards. Many of these counties are in the Appalachian coal mining and power production areas of Kentucky and Tennessee where fugitive dust and stagnant air are particular problems (see Chapter 6). Generally, nonattainment of CO standards was not widespread in the Southeast in 1975 with only 12 counties (5 percent) in violation of primary standards. However, by 1978, worsening air quality in terms of the CO standards was found for Louisville, Charlotte, and Nashville (U.S., NCAQ, 1981) and as shown in Table 11-6, 172 counties violated NAAQS standards for CO in Region 4. In contrast to Region 4, Region 6 ranks first in the percent of counties violating NAAQS standards for ozone with 96 percent or 123 counties; sixth for TSP, seventh for NO_2, and last for both CO and SO_2.

Figure 11-3 shows the specific counties in the Southeast and Southwest which violated NAAQS during 1978-1980 for TSP, SO_2, CO, oxidants, or NO_2 (40 CFR 81.301-344). Many of the nonattainment areas in the Southeast are concentrated near the Appalachian coal fields and power plants in Kentucky, Tennessee, and northern Alabama. In addition, many nonattainment areas surround large cities, including Mobile and Birmingham (Alabama); Atlanta (Georgia); Miami, Tampa, St. Petersburg, Ft. Lauderdale, Tallahassee, and Jacksonville (Florida); Charleston and Columbia (South Carolina); Nashville, Chattanooga, and Memphis (Tennessee); and Louisville (Kentucky). Pollution in major metropolitan areas is discussed further below.

In contrast to Region 4, Region 6 ranks among the best in attaining TSP, SO_2, and CO standards. Less than 2 percent of its counties violated primary SO_2 or CO standards and 3 percent of its counties violated primary TSP standards (U.S., EPA, ORD, 1980a). Local areas within Region 6, however, continue to experience concentrated NAAQS violations. For example, fugitive dust caused the primary particulate standard to be exceeded in at least seven counties in New Mexico (U.S., EPA, Regional Offices, 1980, 1981). Figure 11-3 shows those counties in Region 6 which violated at least one NAAQS. Levels of TSP actually increased in the Houston area from 1975 to 1979. In 1979, Houston, Texas, and Tulsa, Oklahoma, still had problems meeting the NO_2 standards with the NO_2 problem actually deteriorating in Tulsa between 1975 and 1979.

Another criteria pollutant, photochemical oxidants (O_x), is a complex group of chemicals formed when HC and NO_x react in the presence of sunlight. Often known as smog, this pollutant is measured in terms of ozone concentrations. Since automobiles are the major sources of ozone (HC and NO_x), this is primarily a problem in cities. Figure 11-4 indicates violations of the NAAQS for

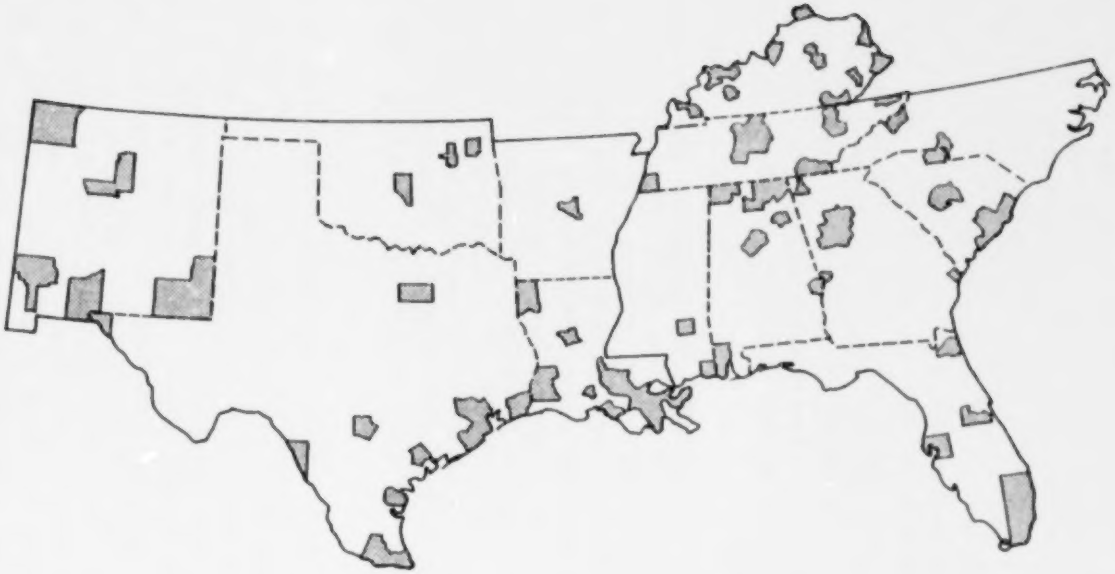
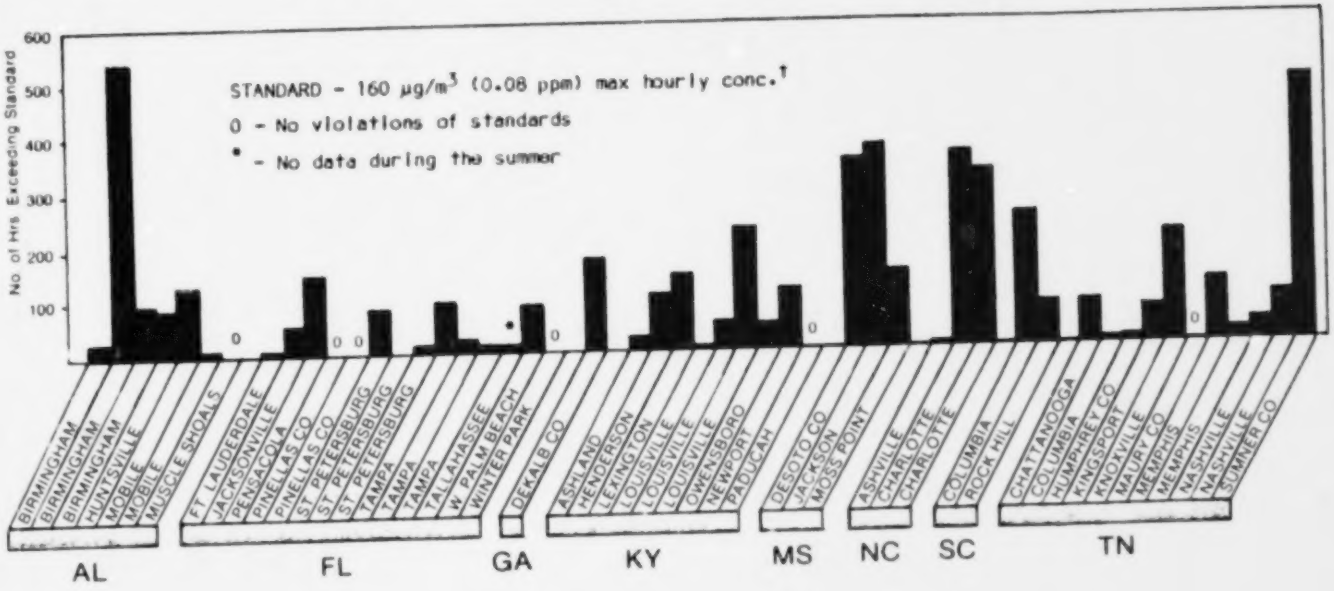


Figure 11-3: Regions 4 and 6 Nonattainment (counties which violated at least one NAAQS, 1978-80).

Source: Map based on data from 40 CFR §81.301-344.

Note: Multiple listings indicate different monitoring stations.



†Recently, the standard was revised upward to 235 μg/m³ (0.12 ppm) maximum hourly concentration

Figure 11-4: Violations of Ozone Standards, Region 4, 1976

Source: U.S., EPA, Region 4, 1978.

ozone in 1976 in major areas of Region 4 (U.S., EPA, Region 4, 1978). Among the worst areas are Birmingham (Alabama), Sumner County (Tennessee), the city of Jackson and Jackson and De Soto Counties (Mississippi) which are just south of Memphis, and Charlotte (North Carolina).

2. Metropolitan Areas

Air quality in metropolitan areas can be characterized by the Pollutant Standard Index (PSI), a health related index adopted by EPA to compare pollution levels uniformly throughout the nation in a way easily reported by the news media. As indicated in Appendix 11B, a value of 100 on this index is considered unhealthful, indicating the potential for mild aggravation of symptoms in susceptible persons and irritation symptoms in healthy populations. Persons with existing health or respiratory ailments are advised to reduce physical exertion and outdoor activity.

The Council on Environmental Quality (CEQ)(U.S., CEQ, 1979) analyzed PSI data for 23 Standard Metropolitan Statistical Areas (SMSA's) for which reliable data existed in the EPA National Aerometric Data Bank to detect trends for the five years 1974-78. Of these 23 SMSA's, 4 are in our study area: Houston, Louisville, Memphis, and Tampa.[1] According to these data, Louisville has shown steady progress in reducing the number of unhealthful, very unhealthful, and hazardous days as indicated by the PSI levels. Tampa and Memphis have experienced relatively few days (under 25 and 50 respectively) of high PSI levels yet the total has fluctuated in each case rather than showing steady improvement. In contrast, Houston has shown a steadily increasing number of days with high PSI levels--from less than 50 days in 1974 to about 100 days in 1978.

CEQ (1980) also ranked 40 large SMSA's, including six SMSA's in the Sunbelt, according to data on violations of the NAAQS. Table 11-7 shows CEQ's data for those six SMSA's in our study area. Five severity classes were used to identify the number of days each SMSA experienced unhealthful air quality. No SMSA's were in the worst class. However, Louisville was in the second worst class, experiencing between 100 and 150 days with PSI readings over 100. For Louisville, CO was responsible for most of the days with an index value over 100.

The three-year average number of unhealthful days for Louisville (119) is considerably higher than for any of the other five

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[1] Eighteen SMSA's were not included because data were not collected by CEQ. Of these eighteen, six are in our study area: Atlanta, Birmingham, Greensboro-Winston Salem-High Point, Fort Lauderdale, Miami, and New Orleans. See U.S., CEQ, 1979.

TABLE 11-7: PSI VALUES FOR SIX SOUTHERN SMSA'S, 1976-1978

		Number of "Unhealthful" Days (PSI over 100)		Number of "Very Unhealthful" Days (PSI over 200)	
Severity Class (PSI >100)	SMSA (rank)	3-Year Average	Minimum-Maximum Annual Days During Three Years	3-Year Average	Minimum-Maximum Annual Days During Three Years
II 100-150 days	Louisville (9)	119	94-160	12	8-14
III 50-99 days	Birmingham[b] (15)	75	50-100	19	8-29
	Houston (17)	69	50-94	16	11-24
IV 25-49 days	Memphis (30)	28	22-37	2	0-3
V 0-24 days	Dallas (34)	22	6-35	1	1-2
	Tampa (35)	12	5-19	1	0-2

Source: U.S., CEQ, 1980.

[a] See Appendix 11B for a description of the PSI.

[b] Based on only two years of data.

SMSA's. The next worst SMSA's are Birmingham (75) and Houston (69). The unhealthful days in Houston can almost entirely be attributed to oxidants, while those in Birmingham can be attributed primarily to particulates (see Table 11-7). In comparison to Louisville, Birmingham, and Houston, the remaining three cities have had considerably fewer unhealthful days. Other cities in Region 4 also have air pollution problems. As shown in Table 11-8, 44 cities were in nonattainment areas in 1977, accounting for approximately nine million people.

TABLE 11-8: CITIES IN NONATTAINMENT AREAS, REGION 4, 1976-1977

State	City	County	Population/1970 SMSA	Population/1970 City	Percent of State Population in Non-attainment
Alabama	Birmingham	Jefferson	767,000	305,893	33
	Gadsen	Etowah		53,928	
	Mobile	Mobile	377,000	190,026	
Florida	Ft. Lauderdale	Broward	620,000	139,590	29
	Miami	Dade	1,268,000	334,859	
	St. Petersburg	Pinellas		216,159	
	Tampa	Hillsborough		277,714	
Georgia	Atlanta	Fulton	1,596,000	495,039	37
	Savannah	Chatham	208,000	118,349	
Kentucky	Corbin	Knox, Whitley		7,317	30
	Hazard	Perry		5,459	
	Henderson	Henderson		22,976	
	Louisa	Kenton		1,781	
	Louisville	Jefferson	867,000	361,706	
	Newport	Campbell		25,998	
	Owensboro	Daviess		50,329	
	Pikeville	Pike		5,205	
	Richmond	Madison		18,907	
	Sheperdsville	Bullitt		2,769	

(continued)

TABLE 11-8: (continued)

State	City	County	Population/1970 SMSA	Population/1970 City	Percent of State Population in Non-attainment
Mississippi	Laurel	Jones		24,145	1
North Carolina	Charlotte	Mecklenberg			
	Newland	Avery		524	>.1
South Carolina	Charleston	Charleston	336,000	66,945	25
	Columbia	Richland	323,000	113,542	
	Georgetown	Georgetown		10,449	
	Rock Hill	York		33,846	
Tennessee	Bristol	Sullivan		25,343	50
	Chattanooga	Hamilton	371,000	166,947	
	Columbia	Maury		21,471	
	Jacksboro	Campbell		689	
	Johnson City	Washington		39,054	
	Kingsport	Sullivan		31,938	
	Kingston	Roane		4,142	
	LaFollette	Campbell		7,262	
	Memphis	Shelby	834,000	657,007	
	Mt. Pleasant	Maury		3,530	
	Nashville	Davidson	699,000	447,877	
	Rockwood	Roane		5,259	
	Tullahoma	Coffee, Franklin		15,311	
	Union City	Obion		11,025	

Source: U.S., EPA, Region 4, 1978.

Despite continuing air quality problems in many metropolitan areas, important examples of significant improvements in air quality exist. Birmingham, Alabama, which has experienced chronic problems in meeting the particulates standard in the past, now seems to have made real progress in local air quality. The number of particulate episodes in that city steadily decreased after 1976 (see Table 11-9) with the last episode recorded in 1978.

TABLE 11-9: BIRMINGHAM PARTICULATE EPISODES, 1971-1981

Year	Status[a]	Number of Episodes
1972	Alert	3
1973	Alert	3
1973	Warning	1
1974	Alert	2
1975	Alert	5
1976	Alert	5
1977	Alert	3
1978	Alert	1
1979	--	0
1980	--	0
1981 (Jan-Aug)	--	0

Sources: Jefferson County Dept. of Health, Air Pollution Control Program; Alabama Air Pollution Control Commission; 40 CFR 51; and Hardy, et al., 1974.

[a] Alert is defined as "Suspended particulate levels of 375 $\mu g/m^3$ (24-hr avg) plus meteorological predictions that conditions will remain unchanged or worsen during the next 12 hours."
Warning is defined as "Suspended particulate levels of 625 $\mu g/m^3$ (24-hr avg) plus meteorological predictions that conditions will remain unchanged or worsen during the next 12 hours."
Emergency is defined as "Suspended particulate levels of 875 $\mu g/m^3$ (24-hr avg)."

One major contributor to metropolitan area nonattainment designations is mobile source emissions. In 1977, for example, mobile sources were responsible for 40 percent of the total HC, 84 percent of the total CO, and 39 percent of the total NO_x emitted into the nation's air (U.S., EPA, Off. of Air Quality Planning and Standards, 1980b, p. vii). Current projections by EPA based on the Strategic Environmental Assessment System (SEAS) model (U.S., EPA, ORD, 1980a) show net HC, NO_x, and CO emissions from mobile sources declining through the year 2000. These projections are based on the assumption of compliance with mobile source abatement requirements and continuing turnover of old, more polluting vehicles in favor of newer less polluting vehicles.[1] However, other factors suggest that mobile source pollution may actually increase or at least fall short of projected decreases. For example, in a recent GAO report (1979), an EPA official stated that many of the cars manufactured on the U.S. assembly lines are not meeting standards for certification. Recent research indicates that under actual driving conditions, at least 80 percent of the American cars will not meet the performance standards established by testing prototype cars (Radian, 1980). In addition, the National Commission on Air Quality (NCAQ)(1981, p. 129) concludes that failure of vehicles to be maintained in such a way as to meet CO emissions standards is a primary reason many states are not meeting the ambient CO standards. Further, according to recent Bureau of Economic Analysis (BEA) data (see Chapter 3), the study area is experiencing increasing urbanization, thus, likely increasing the concentration of mobile source pollution. The Miami-Ft. Lauderdale area, greater Houston, and the Piedmont area of North Carolina and South Carolina near Charlotte are all examples of areas which are experiencing high population growth and consequent air quality problems from mobile source emissions.

11.2.4 Noncriteria Pollutants

In addition to criteria pollutants, control of toxic or hazardous pollutants is of increasing concern because the potential health and ecological effects tend to be more severe, even though fewer people are likely to be exposed to these substances.

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[1] "Net emissions represent pollutants actually released to the atmosphere after all legally required abatement has been achieved" (U.S., EPA, Off. of Air Quality Planning and Standards, 1980a, p.84). These "net emissions" likely underestimate actual emissions to some degree. Moreover, projections of future levels and distribution of emissions by the SEAS model are based on four major assumptions: (1) the increasing substitution of coal for oil and gas as a utility and boiler fuel; (2) the rate at which older electric utilities phase out or are replaced by new facilities which must meet stricter controls; (3) the effects of economic growth, fuel prices, etc., on transportation activities; and (4) the expectation of increasing energy development and accompanying industrial and population growth in the West and Southwest. The SEAS model does not attempt to simulate the regulatory environment. In addition, projections for each criteria pollutant are based on additional factors. For example, SEAS estimates for particulates include only those generated from human sources; those from natural sources, such as fugitive dust in the southwestern states are excluded. See EPA's Environmental Outlook 1980 (U.S., EPA, ORD, 1980a), Chapter 4, "Air Pollutants," for further discussions of the SEAS projections and how they compare with other data such as that from the NEDS.

Unlike the standard-setting process for criteria pollutants which evolved over several years, the regulatory process for hazardous pollutants is only now getting underway (U.S., NCAQ, 1981, p. 76).

At present, seven substances (asbestos, beryllium, mercury, vinyl chloride, benzene, inorganic arsenic, and radionuclides) are listed as hazardous pollutants in Section 112 of the CAA (see Table 11-10) that requires EPA to list hazardous pollutants for which it intends to set national emissions standards with "an ample margin of safety." Of these seven, only four (asbestos, beryllium, mercury, and vinyl chloride) have regulated emissions limits. In addition, an extensive list of 43 other chemicals is undergoing assessment for possible regulatory action. These substances were included on the basis of preliminary evidence of carcinogenicity or other toxicity, volume of emissions, volatility, etc. (U.S., NCAQ, 1981), and would be the priority substances for regulatory action if EPA moves forward with action under Section 112.

However, the difficulties inherent in identifying, screening, and determining the specific health effects of hazardous substances as well as the "threshold" level of exposure are considerable given the uncertainty of current scientific evidence. Since the CAA seems to require zero or near zero emission levels once a hazardous pollutant is identified, the effect on industry can be substantial. Some of the major sources of these types of substances include industries which play a major role in the study area--for example, coal burning, nuclear utilities (see Chapter 6), and the synthetic organic chemical manufacturers and petroleum refineries (see Chapter 7). The study area already has a large share of the petrochemical industry which produces and uses substances such as benzene, chloroform, acrylonitrile, ethylene dichloride, and vinyl chloride. Chemical production is likely to expand throughout Texas and Louisiana in particular.

Considerable uncertainty exists about what the sources are for some trace elements, particularly antimony and cadmium. Among the known major sources of these substances for the study area are electric utilities, industrial boilers, iron and steel production, municipal incinerators, chemical production, and agriculture. Table 11-11 indicates trace element emissions by major source for regions 4 and 6. This table suggests that trace elements are an important concern for the Southwest where over 30 percent of the national totals of selenium and manganese and 20 to 30 percent of the nation's total of fluorine and mercury are emitted. Mercury is a concern in the Southwest, which is responsible for over 30 percent of the national total. Although trace element emissions are small, they represent an environmental hazard because of their toxicity.

TABLE 11-10: PROGRAM STATUS FOR POTENTIALLY HAZARDOUS AIR POLLUTANTS UNDER CAA

• Listed Under Section 111(d): Sulfuric acid mist Fluorides Total reduced sulfur	Pollutants which may endanger public health and welfare, which are not included on lists published for other sections and for which criteria have not been issued. Section 111 provides more flexibility in setting standards of performance than does Section 112.
• Candidates for Section 111(d): Cadmium Trichloroethylene Perchloroethylene Methyl chloroform Methylene chloride Trichlorotrifluoroethane	
• Listed under Section 112: Asbestos Beryllium Mercury Vinyl chloride Benzene Inorganic arsenic Radionuclides	Pollutants which may cause increases in serious illnesses or deaths and for which EPA intends to establish emissions standards providing an "ample margin of safety to protect the public health."
• Current candidates for Listing under Section 112: Acrylonitrile Coke oven emissions	
• Future Candidates for Listing under Section 112: Epichlorohydrin Ethylene dichloride Ethylene oxide Formaldehyde Manganese Nickel Vinylidene chloride	

Source: Adapted from U.S., EPA, Off. of Air Quality Planning and Standards, 1981.

TABLE 11-11: MAJOR SOURCES OF TRACE ELEMENT EMISSIONS FOR REGIONS 4 AND 6, 1975

Trace Elements	Region 4	Region 6
Arsenic	Utilities	Nonferrous metals
Beryllium	Utilities	Utilities
Cadmium	Nonferrous metals	Nonferrous metals
Fluorine	Inorganic chemicals[a]	Inorganic chemicals
Mercury	Inorganic chemicals[a]	Inorganic chemicals[b]
Selenium	Utilities[b]	Nonferrous metals
Manganese	Utilities[b]	Utilities

Source: Adapted from MITRE Corp. et al., 1978.

[a] Region emits between 20 percent and 30 percent of the national total.

[b] Region emits over 30 percent of the national total.

11.3 TRENDS AND ISSUES

11.3.1 Key Driving Forces

Changes occurring in the Sunbelt will continue to have important impacts on air quality issues. Population growth (see Chapters 2 and 3) has been distributed unevenly. For example, nearly all southern metropolitan areas are growing faster than rural areas, and new SMSA's are emerging throughout the South. Almost half of the inmigration has occurred in Florida and Texas, with cities such as Austin, Houston, Ft. Lauderdale, and Tampa (in fact, the entire southern half of Florida) experiencing population increases of over 25 percent between 1970 and 1977 (see Chapter 3).

Many of these growth centers are already experiencing relatively high emissions levels and, in some cases, are nonattainment areas for particulates and ozone. Thus, the growing population results in an increasing number of individuals being exposed to potentially harmful levels of pollutants. Moreover, increasing populations inevitably affect overall levels of human activity, especially in the area of transportation. Most large urban areas in the Southeast and Southwest are already having difficulty controlling mobile source emissions--a problem that is exacerbated by large population growth and urbanization.

In addition to population increases, industrial growth expected in specific locations throughout the study area will contribute to air quality problems. Some segments of the chemical and allied products industry, already an important part of the economy in both the Southeast and Southwest, are expanding production near existing sites throughout the regions (see Chapter 7). The petrochemical industry is expected to increase production levels at plants along the Gulf Coast areas of Texas and Louisiana. This industry is a major emission source for toxic or hazardous pollutants. The development of energy resources in the Four Corners area of New Mexico, the Texas lignite belt, and in the Appalachian areas of Kentucky and Tennessee may be constrained by current air quality standards and, in some cases, will have a significant impact on local air quality conditions (see Chapter 6).

Another industrial development with important implications for local and regional air quality is the emphasis on encouraging the increased use of domestic coal as a substitute for oil and gas, particularly in the states of Texas, Oklahoma, and Louisiana (see Chpater 6). The combustion of fossil fuels is a primary source of air pollution with a particularly large portion of that combustion attributed to electric utilities and industrial users. If these sectors increase coal use, emission levels for TSP, SO_2, and NO_2 will rise depending on the strictness of future controls and total growth of new source emissions (U.S., NCAQ, 1981). After a brief discussion of projections for criteria pollutant emissions in regions 4 and 6, the next section illustrates how such changes in population, industrial growth, and energy development and consumption could impact air quality in the Sunbelt. To accomplish this, it focuses on such issues as the interaction effects and long-range transport of air pollutants, the increasing concentration of people in areas already designated as nonattainment by EPA, and the potential conflicts between air quality standards and plans for local regional growth and development of industry.

A. Region 6

The largest increases in emissions from population and industrial growth are projected to occur in Region 6, an area that currently has relatively low emission levels. This is especially true for projected increases of particulates, SO_2 and NO_x. In contrast to the national emission trend of slightly decreasing levels of net emissions, regional net particulate emissions are expected to increase by approximately 65 percent by 2000 (U.S., EPA, ORD, 1980b, p. 6).[1] The major sources of this increase are projected to be nonferrous metals production, particularly aluminum smelting (70 percent), increased coal use (20 percent), and the construction metals industry. The largest increases in net particulate emissions are expected to occur in Louisiana, Arkansas, and Texas (Honea and Hillsman, 1979a, p. 32).

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[1] Projections are based on the SEAS model. See footnote 1, p. 33 supra.

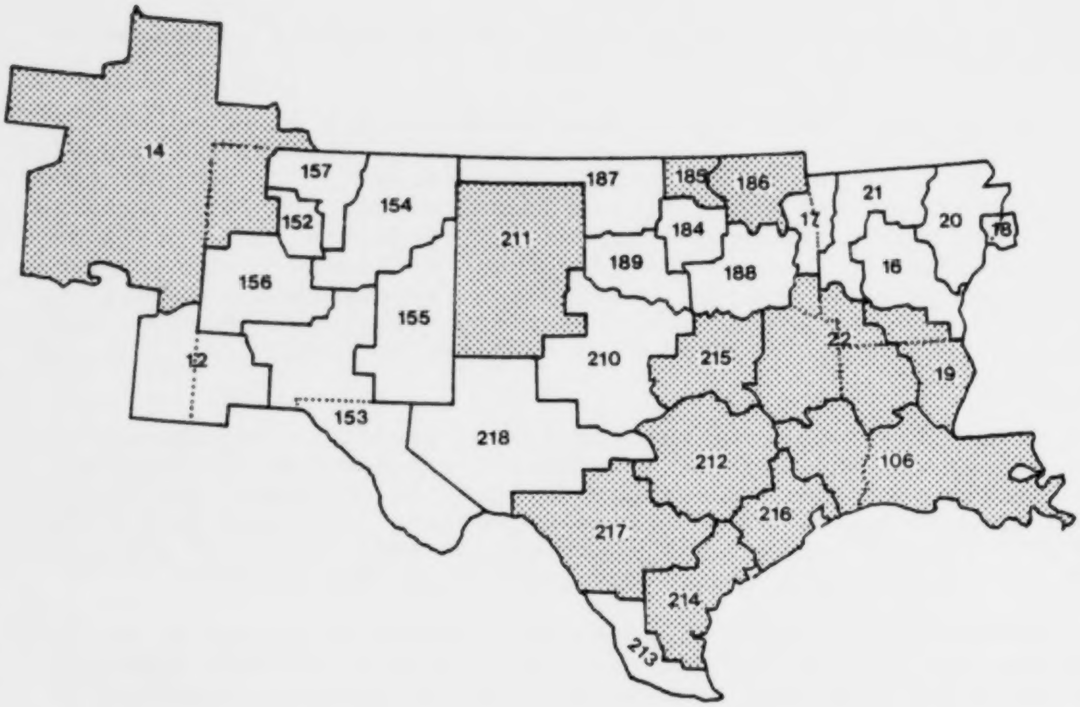
Net SO_2 emissions are expected to increase by as much as 200 percent in Region 6, largely from increased use of coal and lignite and chemical manufacturing. It is estimated that 95 percent of the projected increase in net SO_2 emissions from 1975 to 2000 is due to fuel switching to coal (U.S., EPA, ORD, 1980b, p. 50). A second major contributor to SO_2 emission increases is the overall rising demand for energy to support anticipated population growth and industrial activity in the region.

Figure 11-5 provides additional information on projected SO_2 increases in the Southwest, showing AQCR's with projected SO_2 emission increases greater than 100,000 tpy from 1975 to 1990. For all but two of these AQCR's, the percentage increases are 200 percent or more. The largest increases are projected for the Dallas-Ft. Worth area (867 percent), Shreveport-Texarkana-Tyler (765 percent), and Austin-Waco (725 percent). In terms of total 1990 emissions, southern Louisiana-southeastern Texas (788,000 tpy) and Houston-Galveston (699,000 tpy) have the highest projections. The more general trend emerging from this data is that nearly the entire southeast half of Texas and nearly all of Louisiana are areas subject to rapidly increasing SO_2 emissions. This area is characterized by major current and projected construction of coal-fired power plants and chemical plants.

Net NO_x emissions from electric utilities are expected to increase by about 25 percent by 2000. NO_x emissions from coal-fired industrial combustion are expected to increase by almost 75 percent. This may be partially offset by a net decrease from transportation of about 50 percent (U.S., EPA, ORD, 1980b, p. 7). Net emissions of both HC and CO are expected to decrease in the region, primarily due to transportation emission controls. HC emissions will decrease only slightly, but CO emissions will decrease by about 50 percent (U.S., EPA, ORD, 1980b, pp. 8-9).

B. Region 4

In 1975, Region 4 accounted for about one-fourth of the nation's net particulate emissions, largely from the construction materials industry and old (pre-1976) coal-fired utilities. By 2000, net emissions from electric utilities are expected to be 80 percent lower than in 1975 because of retirement of old utilities and use of new controls. During this same period, net emissions from the construction materials industry are projected to increase about 50 percent, as building activities shift to the South from the Northeast. The net result is a fairly constant



	Air Quality Control Region	SO2 1975	 1990	 % Change
14	Four Corners	203	324	60
19	Monroe-El Dorado	25	118	372
22	Shreveport-Texarkana-Tyler	62	536	765
106	Southern Louisiana-Southeastern Texas	231	788	241
185	Northcentral Oklahoma	19	145	663
186	Northeastern Oklahoma	22	128	482
211	Amarillo-Lubbock	23	175	656
212	Austin-Waco	71	586	725
214	Corpus Christi-Victoria	59	177	200
215	Metropolitan Dallas-Ft. Worth	33	319	867
216	Metropolitan Houston-Galveston	272	699	157
217	Metropolitan San Antonio	22	152	591

Figure 11-5: Air Quality Control Regions in Region 6: AQCR's with Projected SO_2 Emission Increases Greater than 100,000 tpy, 1975-1990[a]

[a] Data taken from Honea and Hillsman, 1979a, pp. 33-34.

level to a slight decline in total net particulate emissions in Region 4.

In contrast, both SO_2 and NO_x emissions are expected to increase in the region. Compared to Region 6, these increases will be at a much slower rate. As shown in Table 11-12, SO_2 emissions in Region 4 are projected to increase 7 percent by 1990 compared to a 105 percent projected increase for Region 6; NO_x emissions are projected to increase by 19 percent in Region 4 and 42 percent in Region 6. However, absolute emissions remain substantially higher in Region 4; in 1990, SO_2 emissions are projected to be in excess of 9 million tpy compared to about 5 million tpy in Region 6.

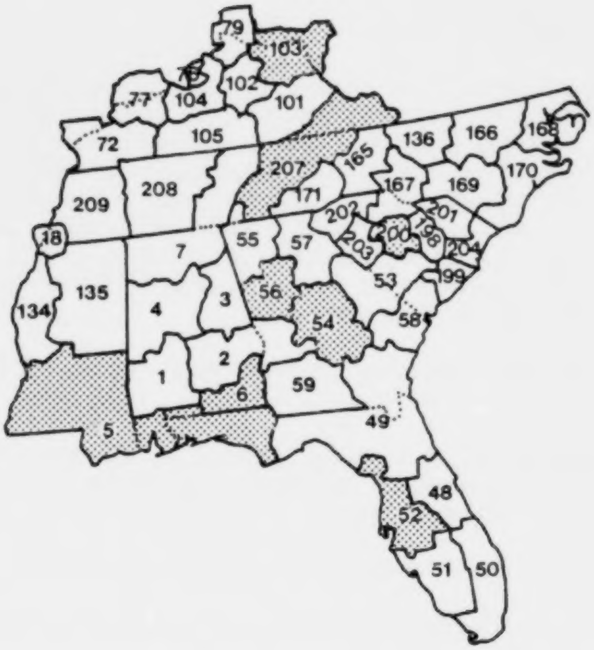
Figure 11-6 provides information on projected SO_2 emissions for Region 4. The highest emissions are projected for the AQCR of Huntington-Ashland-Portsmouth-Ironton in northeast Kentucky--over 900,000 tpy by 1990. Large percentage increases from 1975 to 1990 are projected for the central Georgia AQCR (267 percent) and for the Columbia (South Carolina) AQCR (248 percent).

Emissions of CO are expected to decrease in Region 4, as they are for the rest of the nation. This largely reflects expected decreases in emissions from transportation sources; however, if vehicle-miles driven continue to increase, these decreases may be offset by a total net increase in emission levels. The pulp and paper industry is also projected to increase its importance as a source of CO by the year 2000 unless pollution controls are required for this industry. Projected increases range from 100 percent to 150 percent (U.S., EPA, ORD, 1980a, pp. 109-13).

TABLE 11-12: ANNUAL SO_2 AND NO_x EMISSIONS, 1975-1990
(thousands of tpy)

	SO_2		NO_x	
	Region 4	Region 6	Region 4	Region 6
1975	8,584	2,483	3,898	2,713
1990	9,177	5,103	4,627	3,852
Net Change	+ 583	+2,620	+ 729	+1,130
% Change	7	105	19	42

Source: Data taken from Honea and Hillsman (1979a, p. 33; 1979b, pp. 33-34).



	Air Quality Control Region	SO_2		
		1975	1990	% Change
5	Mobile-Pensacola-Panama City Southern Mississippi	504	689	37
6	Southeastern Alabama	1	172	172
52	Westcentral Florida	497	609	23
54	Central Georgia	75	260	267
56	Metropolitan Atlanta	105	217	107
103	Huntington-Ashland-Portsmouth-Ironton	699	916	31
200	Columbia	58	202	248
207	Eastern Tennessee-Southwestern Virginia	611	749	23

Figure 11-6: Air Quality Control Regions in Region 4: AQCR's with Projected SO_2 Emission Increase Greater than 100,000 tpy, 1975-1990[a]

[a] Data taken from Honea and Hillsman 1979b, pp. 33-35.

11.3.2 Problems and Issues

A. Acid Deposition

Concern has increased recently over the potential effects from the interaction of pollutants. Perhaps the most serious of these effects is the phenomenon known as acid precipitation or "acid rain" formed by the transformation of SO_x and NO_x into acidic ions.[1] Approximately 55 million tons of SO_2 and NO_x are discharged into the air annually from man-made sources (U.S., EPA, Off. of Air Quality Planning and Standards, 1980c). These pollutants can be converted into acids and return to earth in dew, rain, snow, or dry deposition.

Research on acid precipitation has reported six potential categories of effects (U.S., EPA, ORD, 1979):

- Acidificaiton of lakes, rivers, and ground waters resulting in damage to fish and other components of aquatic ecosystems;
- Acidification and release of metals from soils;
- Possible reductions in forest productivity;
- Possible damage to agricultural crops;
- Deterioration of man-made materials such as buildings, statuary, metal structures, and paint; and
- Possible contamination of drinking water supplies by metals being released from soils and pipelines.

This type of evidence is preliminary. However, an expert panel of the National Research Council has concluded that the acid rain situation "is disturbing enough to merit prompt tightening of restrictions on atmospheric emissions from fossil fuels and other large sources" (NRC, 1981, p. 7).

Because of the volume of precursor pollutants (SO_x and NO_x), acid precipitation has become an increasing concern, particularly in the northcentral and northeastern U.S. Considerable portions of the study area are also subject to such deposition, including much of Region 4. Existing research seems to suggest that the effects of such deposition vary widely depending on local conditions. Figure 11-7 indicates potential sensitivity throughout Region 4 to acid deposition, based on soil composition. Virtually all of Region 4 is believed to be somewhat sensitive. The worst areas appear to be central Alabama and Georgia, eastern Tennessee, and western North Carolina. In 1979, for example, four rains in North Carolina were measured at a pH 3.3 (U.S., EPA, ORD, 1979), which is close to that of vinegar. The Charlotte Observer now routinely reports rain acidity on its weather page.

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[1] The pH (acidity/alkalinity) scale, based on a solution's concentration of hydrogen ions (H+), is used to determine the strength of an acid. The scale ranges from 0 (very acidic) to 14 (very alkaline). Because the scale is logarithmic, pH 4 is 10 times more acidic than pH 5, and 100 times more acidic than pH 6, and so on. Precipitation is defined as acidic if the pH is less than 5.6, the pH of normal, unpolluted rain.

Sulfur and nitrogen oxide emissions from local utility and coal industries are substantial in much of the Southeast. In addition, acidic conditions are supported by transported pollutants --from as much as 500 miles away (Ganon, 1978). Long-range transport of acidic ions has increased in recent years through expanded construction of smelter and power plants with tall exhaust stacks (U.S., NCAQ, 1981, p. 242). Initially, these tall stacks were, for the most part, constructed to dispense pollutants widely in order to meet local ambient air quality standards. Although stack heights are now encompassed in the regulatory system, existing tall stacks continue to contribute to long-range transport of pollutants and the likelihood of conversion with acid deposition. Estimates by both the Department of Energy and the Federal Aviation Administration identify the East Northcentral, South Atlantic, East Southcentral and Middle Atlantic regions as having the largest number of tall stacks (U.S., CEQ, 1980). The majority of the tallest (800 feet or higher) stacks built by electric utilities are in the South Atlantic states (see Table 11-13) which include the study area states of Florida, Georgia, North Carolina, and South Carolina. Out of the total of 186 stacks in excess of 500 feet built by electric utilities between 1970 and 1979, 53 were in the Northcentral states, 39 were in the South Atlantic states, and 29 in the East Southcentral states of Alabama, Kentucky, Mississippi and Tennessee.

Among the effects of acid deposition currently being investigated, two seem particularly relevant to our study area. The effects on forest ecosystems are a particular concern in the Southeast, both because of plans for increased forest productivity (see Chapter 9) and the direct economic importance of the pulp and paper industry to the study area. Although industry in general seems to be taking a cautious view toward regulatory responses to the acid rain issue the paper industry's unique role in the acid rain debate is indicated in the conclusion to a "state-of-knowledge" report issued by the National Council of the Paper Industry for Air and Stream Improvement (1981, p. 58).

> On the one hand, the manufacturing facilities of the industry emit sulfur and nitrogen oxides which are thought to be precursors of acidic deposition. If

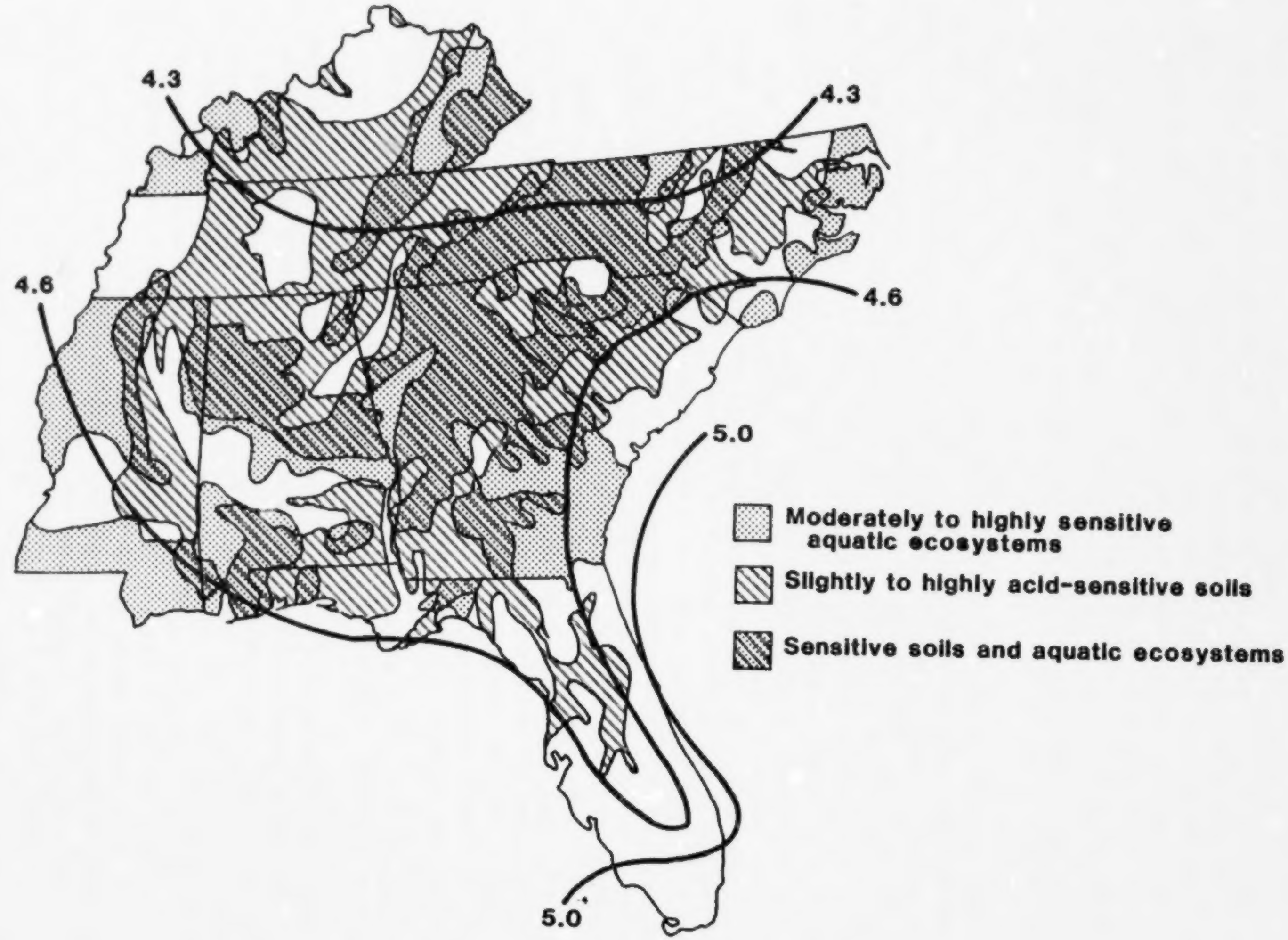

4.3
4.3
4.6
4.6
5.0
5.0
▤ Moderately to highly sensitive aquatic ecosystems
▨ Slightly to highly acid-sensitive soils
▩ Sensitive soils and aquatic ecosystems

Figure 11-7: Sensitivity to Acid Rain

Source: U.S., EPA, ORD, 1979, p. 5.

TABLE 11-13: REGIONAL DISTRIBUTION OF TALL STACKS BUILT BY ELECTRIC UTILITIES, 1970-1979

	Stack height (ft)				
Region	>800	700-799	600-699	500-599	Total
New England[a]	--	--	--	7	7
Middle Atlantic[b]	2	7	7	5	21
East Northcentral[c]	11	4	11	27	53
West Northcentral[d]	1	5	7	5	18
South Atlantic[e,f]	15	9	7	8	39
East Southcentral[f,g]	8	6	7	8	29
West Southcentral[f,h]	--	1	3	1	5
Mountain[f,i]	--	--	3	4	7
Pacific[f,j]	--	--	1	--	1
Total	37	33	46	70	186

Source: Cramer, 1979.

[a] Includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

[b] Includes New Jersey, New York, and Pennsylvania.

[c] Includes Illinois, Indiana, Michigan, Ohio, and Wisconsin.

[d] Includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

[e] Includes Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia.

[f] Includes states in Regions 4 or 6.

[g] Includes Alabama, Kentucky, Mississippi, and Tennessee.

[h] Includes Arkansas, Louisiana, Oklahoma, and Texas.

[i] Includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Wyoming.

[j] Includes California, Oregon, and Washington.

additional SO_x and NO_x control measures on combustion sources are eventually mandated as a strategy to reduce acidic deposition and its adverse effects, the industry will bear a significant share of these control costs. On the other hand, the industry's raw material base is in the forest and even a slight reduction in forest productivity as a consequence of acidic deposition would represent a major adverse impact. At the present time the evidence of such adverse effects is inconclusive, but it is essential that the industry develop an information base adequate to resolve this issue.

Research on crop forest growth has not yielded conclusive evidence on the direct effects of acid rain; in fact, areas lacking sulfates and nitrates may actually benefit from acid rain (U.S., CEQ, 1981). However, some experts predict long-term damage (Ember, 1981, p. 24). A report by the National Research Council (1981) raises the concern that acid rain increases the amount of toxic metals which reach water bodies. It concluded that "there is no satisfactory technology for controlling large-scale emissions of mercury," a metal which in acting synergistically with acid rain might cause chronic problems in specific locations (NRC, 1981, p. 4). As indicated in Table 11-11, during 1975, over 30 percent of the nation's mercury emissions occurred in the Southcentral states of Region 6 while between 20 and 30 percent of the mercury emissions were in Region 4.

In addition, total SO_x emissions are expected to increase in areas of central Georgia and metropolitan Atlanta, eastern Tennessee near the Smokey Mountains National Park, and westcentral Florida surrounding Tampa-St. Petersburg (see Figure 11-6). Region 6 is projected to have substantial increases in SO_x emissions throughout an extensive area along the Gulf Coast of Texas and Louisiana (see Figure 11-5). Continuing research on the causes and impacts of acid precipitation is providing information which seems to have serious implications for the plans to increase coal use in these areas (U.S., GAO, 1981).

B. Population Growth in Nonattainment Areas

The South has been growing in both metropolitan and nonmetropolitan areas. In fact, while most of the rest of the country has experienced declining metropolitan growth, regions 6 and 4 rank first and second in such growth (see Chapter 3). Between 1970 and 1977, 31 metropolitan areas experienced a growth rate of at least 15 percent (see Chapter 3, Appendices) and many of these grew at a rate of 25 percent or more. Of these metropolitan areas, the 9 "high growth" areas are all in either Texas or Florida. Together, these 31 areas represented 36 percent of the total population of the study area in 1977, and growth in these areas accounted for 54 percent of the total growth in the study area between 1970 and 1977. One of the most significant potential problems associated with such rapid population growth is declining air quality. This is manifested through (1) the increased use of motor vehicles in urbanized areas, which can lead to deteriorating air quality through increased emissions of CO, HC, and NO_x; and (2) the clustering of population in areas, which fail to meet the NAAQS, which represents an increased health risk for those people. In the South, many of the high growth areas are currently designated as nonattainment by EPA and in some instances projected to remain nonattainment areas through 1982 or 1987 (40 CFR §81.301-344, 1980; U.S., NCAQ, 1981).

Ozone, formed from the interaction of HC and NO_x, is considered a serious problem in almost every metropolitan area in the country. In the Sunbelt, rapidly growing metropolitan areas along the Gulf Coast from Corpus Christi, Texas, to Mobile, Alabama, are nonattainment areas for ozone as are the high growth areas of Albuquerque, New Mexico; El Paso, Texas; and Charlotte, North Carolina. Trends for CO levels improved in the Birmingham, Alabama, area but actually deteriorated between 1975 and 1979 in Louisville, Kentucky; Charlotte, North Carolina; and Nashville, Tennessee. Houston, Texas and Tulsa, Oklahoma continue to experience problems meeting NO_2 standards (U.S., NCAQ, 1981).

Figure 11-8 shows those areas in regions 4 and 6 which are projected to be potential nonattainment areas for ozone, CO, TSP, and SO_2 in 1982 (U.S., NCAQ, 1981), Factors that affect the accuracy of these projections include possible changes in the NAAQS themselves, changes in economic and population growth trends, expansion and improvements in monitoring, or changes in institutional relationships and priorities.

A substantial percentage of the Region 4 population--for example, 50 percent in Tennessee and 33 percent in Alabama--live in nonattainment areas (U.S., Dept. of Commerce, Bur. of the Census, 1978, 1979; U.S., EPA, Region 4, 1978). As these metropolitan areas in the Southeast continue to grow, mobile source pollution, primarily from automobiles, is likely to increase. For example, despite the new control systems reducing emissions from new cars, the expected total reductions have been offset nationwide by a 30 percent increase in motor vehicle miles traveled since 1970 (U.S., EPA, Com. on Monitoring and Info. Mgmt., 1980); failure of vehicles to meet performance and maintenance standards (U.S., NCAQ, 1981; Radian, 1980); and rapid growth of stationary source emissions (U.S., NCAQ, 1981). Thus, despite expected improvement in air quality across the nation, many areas in the study region with large and growing populations are likely to experience increased health risks from exposure to high levels of air pollutants.

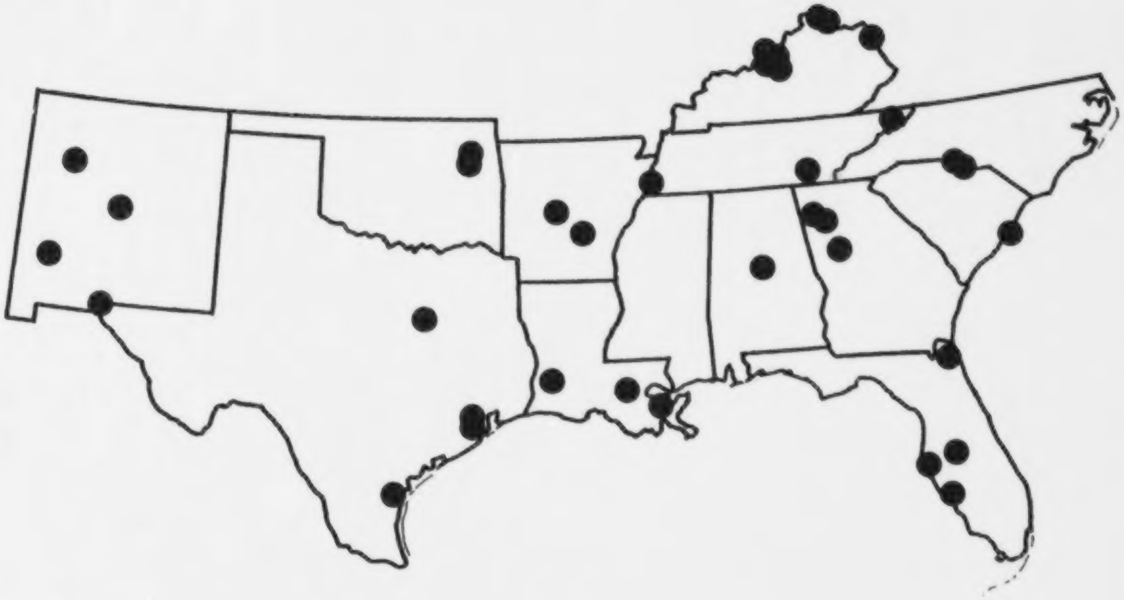


Figure 11-8: Projected Nonattainment Areas for Regions 4 and 6

Source: U.S., NCAQ, 1981.

C. Industrial Growth in the Sunbelt

The Gulf Coast of Texas, particularly in the Houston area, has experienced rapid growth in population, industry, and energy development over the past decade and is projected to continue as a growth center in the future (see Chapters 3 and 4). However, some of this expected industrial and energy development could be limited in the future by restrictions in the Prevention of Significant Deterioration (PSD) Program implemented by EPA under the CAA Amendments passed by Congress in 1977.

The PSD program is intended (1) to maintain the quality of air that was already cleaner than required by the NAAQS in order to protect public health; (2) to limit total tonnage of pollutants entering the atmosphere in order to minimize long-range transport problems such as acid rain and impaired visibility; (3) to protect pristine areas with aesthetic values such as parks and wilderness from visual impairment; (4) to enable states to compete for industry without having to use air quality as a bargaining chip; and (5) to limit the degradation of clean air by SO_2 and TSP on both an annual and daily basis (U.S., NCAQ, 1981).

A major part of the program is the review required prior to construction of new and modified stationary pollution sources to be sure that they will not significantly degrade air quality in areas where the air is cleaner than national standards--this includes portions of the 90 percent of the nation's counties that meet or are unclassified for TSP, the 97 percent that meet or are unclassified for the SO_2 standard, and any areas meeting any of the other pollutant standards (Alabama Power v. Costle, 1979).

Another major part of the program is the protection of air quality values in three classes of PSD areas ranging from Class I areas which protect the most pristine areas (national parks, wilderness areas, etc.) and allow virtually no pollution increases, to Class III areas which essentially allow pollution up to the NAAQS. Class I areas include those national parks and wilderness areas mandated by Congress and other federal lands redesignated as Class I by the Departments of Interior and Agriculture. Currently, 159 Class I areas have been designated nationwide. Figures 11-9 and 11-10 identify Class I areas in the Sunbelt. These states have very few Class I areas in comparison to the western U.S. where most Class I areas exist. However, in the Southeast the two major Class I areas, the Great Smokey Mountains National Park and the Everglades National Park, are very close to areas with high emissions and/or nonattainment areas and thus have already experienced problems with photochemical smog (U.S., NCAQ, 1981). In Region 6, New Mexico has nine Class I areas, which could affect mining and other energy developments. In general, however, the virtual absence of Class I areas throughout the rest of the region may increase siting flexibility for industrial growth compared to many potential locations in the western U.S.

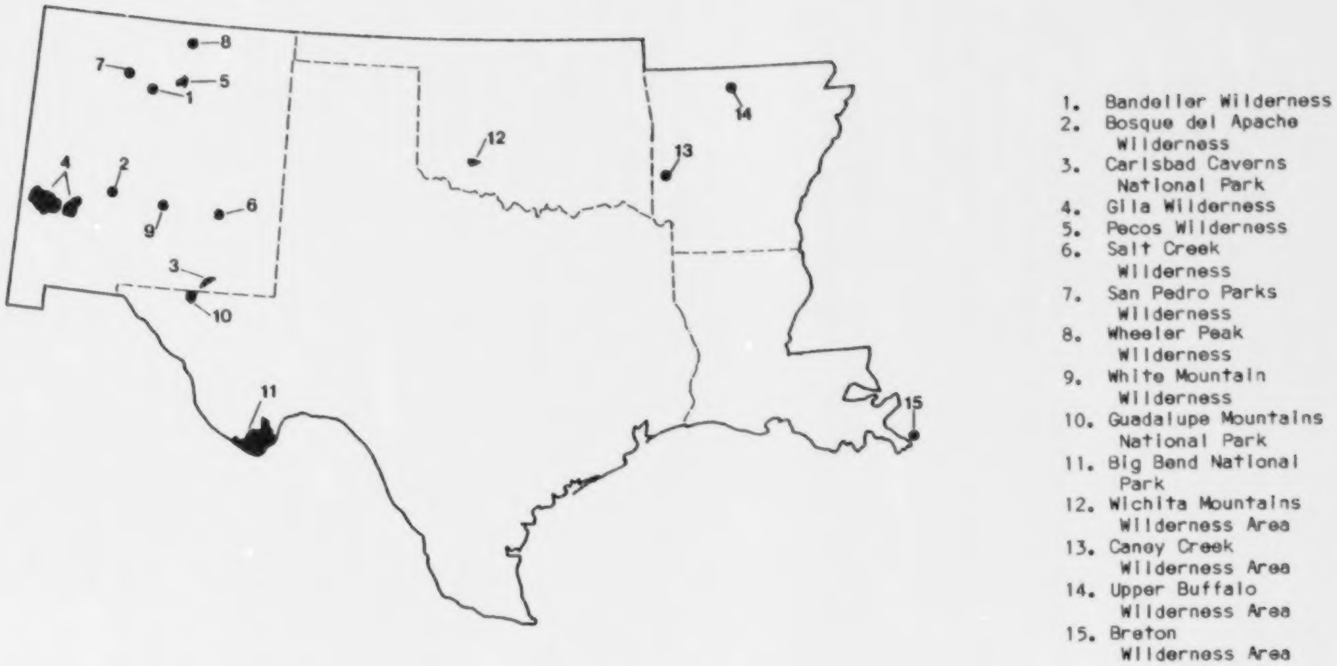
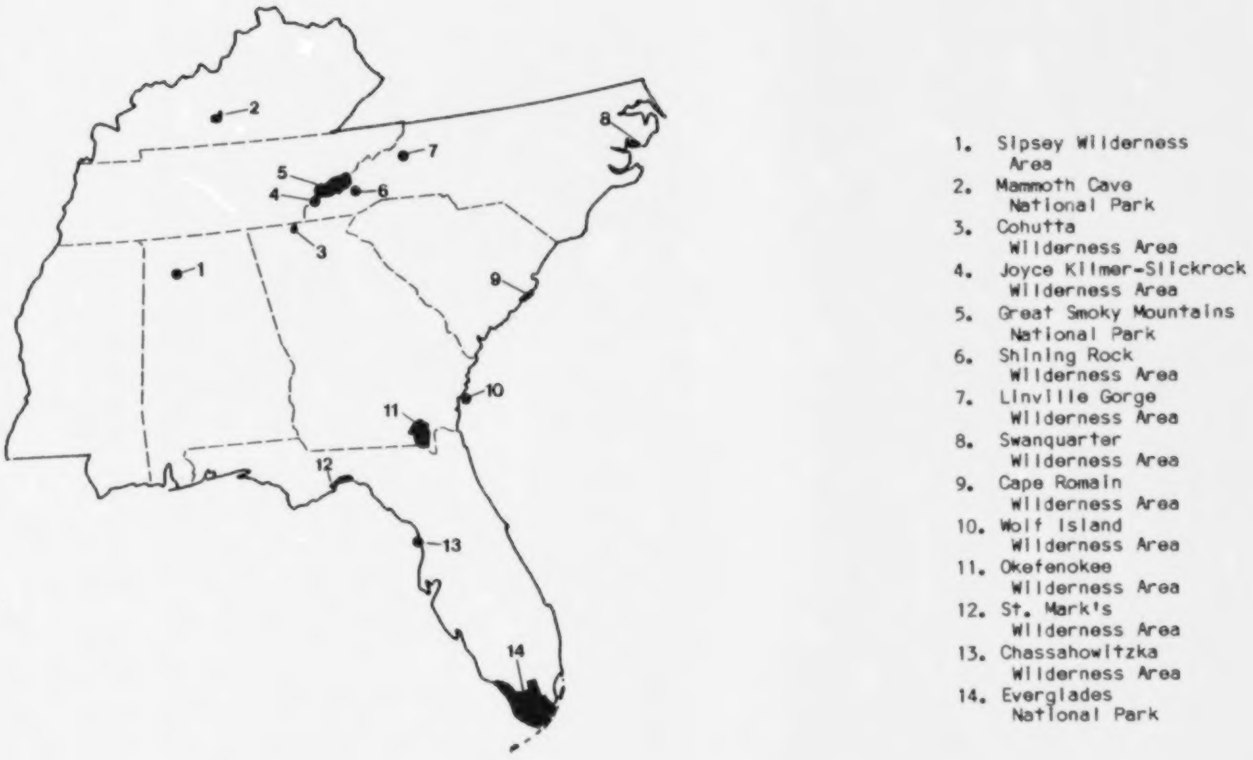

1. Bandelier Wilderness
2. Bosque del Apache Wilderness
3. Carlsbad Caverns National Park
4. Gila Wilderness
5. Pecos Wilderness
6. Salt Creek Wilderness
7. San Pedro Parks Wilderness
8. Wheeler Peak Wilderness
9. White Mountain Wilderness
10. Guadalupe Mountains National Park
11. Big Bend National Park
12. Wichita Mountains Wilderness Area
13. Caney Creek Wilderness Area
14. Upper Buffalo Wilderness Area
15. Breton Wilderness Area

Figure 11-9: Class I Areas in Region 6

Source: Honea and Hillsman, 1979a; 40 CFR §81.401-437, 1980.


1
2
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1. Sipsey Wilderness Area
2. Mammoth Cave National Park
3. Cohutta Wilderness Area
4. Joyce Kilmer-Slickrock Wilderness Area
5. Great Smoky Mountains National Park
6. Shining Rock Wilderness Area
7. Linville Gorge Wilderness Area
8. Swanquarter Wilderness Area
9. Cape Romain Wilderness Area
10. Wolf Island Wilderness Area
11. Okefenokee Wilderness Area
12. St. Mark's Wilderness Area
13. Chassahowitzka Wilderness Area
14. Everglades National Park

Figure 11-10: Class I Areas in Region 4

Source: Honea and Hillsman, 1979b.

Studies to date have not documented the effect of the PSD program on interregional location decisions by industry or on restricting energy development, but rather suggest that the effect has been one of modifying siting choices or control strategies within an area. However, Kentucky has reported that approximately 8 to 10 small sources of emissions relocated across the Ohio River (in Indiana) in part because of less stringent PSD regulations there in comparison with their own nonattainment regulations (Offhutt, 1980).

The effects of PSD on energy development in regions 4 and 6 have not been major to date. New Mexico, like much of the Southwest, is sensitive to the visual impact of particulates from power plant emissions, automobile emissions, smelter emissions, and wind-blown soil and fugitive dust from agricultural, mining and construction activities. The Four Corners area has been of partiular concern because of extensive energy development planned there (see Chapter 6). The assumption of stringent controls on emissions has led some experts to conclude that air quality will not be a major concern. Yet considerable evidence of long-range transport from California into that area and some inadequacies in dispersion modelling have raised some concerns over that assumption (U.S., NCAQ, 1981).

Another concern is the effect of fuel switching on air quality and as a limiting factor for industrial and energy development in an area since different fuels alter the types and quantities of pollutants emitted. The ability of an industry to switch fuels in response to economic factors is very important. Under the PSD regulations, the use of different fuels required by the Department of Energy conversion orders and nautral gas curtailment plans is not considered as source of modification subject to review (U.S., NCAQ, 1981). Although a national federal coal conversion program has not yet been implemented, the impact of such a program as well as voluntary, incremental conversions could have important cumulative impacts in some regions. Energy development in the Gulf Coast area could be limited if existing sources convert to the higher sulfur fuels allowed under current regulations. Such switching could result in higher levels of SO_2 emissions which would limit further energy growth in the area.

The largest SO_2 increases for Region 6 by 1990 are expected in the Dallas-Ft. Worth area (867 percent), Shreveport-Texarkana-Tyler (765 percent), and Austin-Waco (725 percent) (Honea & Hillsman, 1979a). In terms of total 1990 emissions, southern Louisiana-southeastern Texas (788,000 tpy) and Houston-Galveston (699,000 tpy) are projected to have the highest levels of SO_2. Contributing to this dramatic projected increase in emissions for SO_2, as well as NO_x, TSP, and volatile organic compounds, are the plans for multiple energy development. This includes mining of lignite and lignite power production throughout the lignite belt of Southeast Texas (see Chapter 6), uranium mining, and substantial increases in chemical production and coal-fired industrial combustion. Houston has already begun to participate in an emission offset banking program in order to facilitate planning and provide more certainty for industries wanting to locate there or expand existing facilities. The chemical industry decreased its nonmethane HC emissions between 1974 and 1978 by 34 percent. However, rapid source growth in the chemical and other industries resulted in an overall absolute growth in HC, NO_x, and SO_2 emissions. Thus, while PSD regulations themselves are not expected to limit growth, air quality concerns can be expected to shape the character and rate of growth in areas like the southeast and Gulf Coast areas of Texas which are experiencing relatively rapid development of increased pollution sources like fuel combustion plants, chemical producers, and vehicles (U.S., NCAQ, 1981)

11.4 SUMMARY

Like much of the nation, the Sunbelt has experienced some successes in improving its air quality. Moreover, both the Southeast and Southwest have air quality which generally is good in comparison to that in the heavily industrialized northeastern and northcentral states. The changes occurring throughout the Sunbelt raise a number of concerns about future air quality problems, as summarized in Table 11-14.

In contrast to the national trend of decreasing levels of SO_x emissions, the southeastern Gulf Coast areas of Texas could continue to experience increasing SO_x emissions because of rapidly increasing industrialization and switching to coal from oil or natural gas by existing industrial facilities. This upward trend is from a relatively low base, since all of Region 6 contributed only 9 percent to the national total SO_x emissions in 1978. However, the area of Texas in which much of this growth is occurring already contributes over one-half of the total SO_x emissions in Region 6. Thus, air quality regulations may require increasing attention to siting choices and control strategies in the future.

The Ohio River Basin especially with its substantial number of coal-fired power plants is of particular concern for both SO_x emissions and TSP. The Basin contributes to local nonattainment problems and, under specific meteorological conditions, is believed to contribute significantly to long-range transport problems in parts of the Southwest and the Southeast. Texas and Louisiana could also contribute increasing air pollutant loads to the Southeast when southwesterly winds prevail.

Long-range transport of pollution is receiving increasing attention. Of particular concern are hydrocarbons and nitrogen oxides which contribute to ozone, and sulfur dioxide which can be

TABLE 11-14: PROBLEM CHARACTERIZATION MATRIX: AIR QUALITY

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problems
• Acid deposition	• Industrial growth and fuel switching • Energy development • Meteorological conditions • Sensitivity of terrestrial and aquatic ecosystems • Tall stacks	• Ecological • Economic	• This is a long-term problem expected to worsen in the future if SO_x and NO_x emissions are not adequately controlled	• Most of the Southeast, especially the Carolinas, Alabama, Georgia, Mississippi, Tennessee, Louisiana, and the Gulf Coast area of Texas are believed to be vulnerable to the effects of acid deposition.	• The problem is not as severe at present time in the Sunbelt as it is in the northeastern U.S. and in Canada. Effects are not fully understood but include potential damage to lakes, forests, and crops. Human health effects are not known.	• Because of the role of long-range transport of pollutants in contributing to acid deposition, intergovernmental cooperation will be neccessary. This has become an international policy issue. • Regulatory responses will be particularly difficult to formulate in the midst of current uncertainty.
• Population growth in non-attainment areas	• Rapid growth in metropolitan areas • Increasing number of vehicle-miles driven • Local air dispersion patterns	• Human health • Ecological • Economic • Aesthetic	• This is both a current and long-term problem. The number of violations for some criteria pollutants is decreasing. However, ozone (photochemical smog) seems to be particularly resistant to control efforts.	• Localized depending on the major sources of emissions. Ozone is the most pervasive problem, especially in large cities such as Houston, Nashville, Charlotte, Atlanta, Louisville, etc.	• Human health effects are not completely known. However, violations of standards seem to occur most frequently near urban areas where the concentration of the population-at-risk is greater. • Costs of controlling pollutants can be expensive.	• Regulatory strategies and the basic law setting forth the framework for NAAQS are undergoing considerable debate and at least some revision creating uncertainty both for those trying to meet the standards and those trying to enforce the standards.

(continued)

TABLE 11-14: (continued)

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problems
• Constraints on Industrial growth	• Industrial expansion and fuel switching • Energy development • Local air dispersion patterns • Rapid new source of growth • PSD classification • Technological constraints	• Economic • Human health	• A current and long-term problem because of scientific uncertainties and regulatory problems	• Rapid new source growth and Industry expansion seems to be concentrating particularly along the Gulf Coast. • SO_2 and TSP violations continue to be a problem especially around the large coal-fired power plants in Florida, Kentucky, and Tennessee. TSP continue to be a problem in the Ohio River Basin area of Kentucky, Tennessee, and much of Region 6. • Impacts of hazardous emissions are usually very localized, although the extent of local exposure is considered widespread in the Southeast and Southwest because of the emissions of trace metals and suspected carcinogens by a variety of Industries.	• Siting choices and control strategies may need to be modified, thus critically affecting Industry costs. • Hazardous substances are particularly serious because of their suspected carcinogenicity. Therefore, even though fewer people are exposed, the effects are believed to be much more serious than from the criteria pollutants. Moreover, in the case of organic chemicals and trace metals, the effects are usually latent and possibly irreversible.	• The regulations, as they stand, are extremely complex and difficult to understand or interpret. • Some PSD regulations have been cumbersome to implement and could be better coordinated with other air quality regulations and goals. • The large number of potentially hazardous pollutants and the lack of scientific certainty in establishing causal relationships between the specific substances and human health effects makes the regulatory process of identifying and screening difficult.

transformed into particulate sulfates and is a precursor of acid deposition. The acid deposition issue is controversial in both the scientific and political sense. While consensus exists that acid deposition is occurring as a result of transport and interaction of air pollutants, the extent, rate and timing of these processes are not completely understood. Most of Region 4 and the southeastern edge of Region 6 along the Gulf Coast are believed to be sensitive to acid deposition; thus, the Sunbelt may have increasing problems with forestry and agricultural production as well as wetlands preservation.

Hazardous pollutants, primarily those known as volatile organic compounds, also appear to be an increasing source of concern, especially in the Gulf Coast areas of Texas and Louisiana where the chemical and petroleum industries are expected to increase production levels in the future. To date, very few of these pollutants have been regulated, yet the potential effects of concentrations of these pollutants can be very serious for human health.

Growth and development in the Sunbelt has not been significantly restricted by air quality regulations to date. However, areas such as southern Florida, the Ohio River Basin area in Kentucky, counties in Tennessee and Alabama with large coal-fired electric generation and industrial plants, and the Gulf Coast area of Texas and port areas of Louisiana may find it increasingly necessary to use innovative regulatory programs to meet existing air quality standards. Cumulative population growth in these areas will increase the number of people at risk as well as the local mobile source emissions problem. Increasing industrialization and energy development will affect the potential interaction of pollutants and continue to raise air quality concerns for the future.

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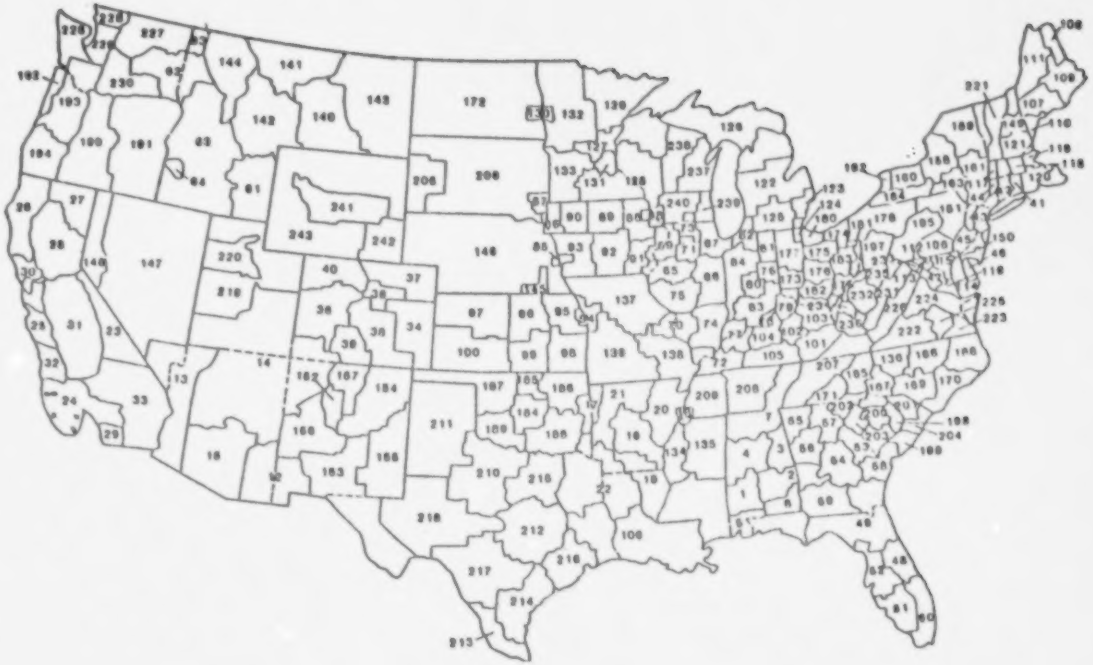


Appendix 11-A: Boundaries of Air Quality Control Regions

Source: Pechan, Edward H. 1977. 1985 Air Pollution Emissions.
Washington, D.C.: U.S., Department of Energy.

APPENDIX 11-B: COMPARISON OF POLLUTION STANDARD INDEX

Index Value	Air Quality Level	Pollutant Levels					Health Effect Descriptor	General Health Effects	Cautionary Statements
		TSP (24-hr.), µg/m³	SO_2 (24-hr.), µg/m³	CO (8-hr.), µg/m³	O_3 (1-hr.), µg/m³	NO_2 (1-hr.), µg/m³			
500	Significant Harm	1,000	2,620	57.5	1,200	3,750		Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keeping windows and doors closed. All persons should minimise physical exertion and avoid traffic.
400	Emergency	875	2,100	46.0	1,000	3,000	Hazardous	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid outdoor activity.
300	Warning	625	1,600	34.0	800	2,260	Very Unhealthful	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity.
200	Alert	375	800	17.0	400[a]	1,130	Unhealthful	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity.
100	NAAQS	260	365	10.0	160	b			
50	50% of NAAQS	75[c]	80[c]	5.0	80	b	Good		
0		0	0	0	0	b			

Source: U.S., Environmental Protection Agency (EPA), "Guidelines for Public Reporting of Daily Air Quality-Pollution Standard Index."

[a] 400 µg/m³ was used instead of the O_3 Alert Level of 200 µg/m³.

[b] No index values reported at concentration levels below those specified by "Alert Level" criteria.

[c] Annual primary NAAQS.

APPENDIX 11-C: PARTICULATE EPISODE CRITERIA

Episode Stage	Conditions
Forecast of watch	Issuance of an Air Stagnation Advisory by National Weather Service
Alert	Suspended particulate levels of 375 $\mu g/m^3$ (24-hr avg) plus meteorological predictions that conditions will remain unchanged or worsen during the next 12 hours
Warning	Suspended particulate levels of 625 $\mu g/m^3$ (24-hr avg) plus meteorological predictions that conditions will remain unchanged or worsen during the next 12 hours
Emergency	Suspended particulate levels of 875 $\mu g/m^3$ (24-hr avg) plus meteorological predictions that conditions will remain unchanged or worsen during the next 12 hours

Source: Abstracted from 40 CFR 51.

CHAPTER 12

LAND AND COASTAL ZONE USE

HIGHLIGHTS

- Status and Trends

1. Coastal zone water pollution has improved dramatically in several Gulf Coast and Atlantic Coast bays and estuaries such as Charleston Bay, Escambia Bay and Perdido Bay. Further improvement in industrial and municipal discharges will continue to enhance the quality of coastal waters.

2. Increases in trade and the development of offshore resources have contributed to the industrialization of the coastal zone. The major port areas of Houston, New Orleans, Tampa, and Jacksonville are examples of this growth. Anticipated increases in the grain exports and in the chemical, textile, and paper industries of the Southeast also suggest further industrialization.

3. Marine fisheries are affected by the quality of the coastal environment and the intensity of human utilization. The Gulf Coast white shrimp fishery, for example, has been depleted by coastal pollution, salt water intrusion, and by reduction in nursery grounds by dredging and landfills. Despite increased fishing effort, the harvest of the resource has declined.

4. The U.S. Soil Conservation Service inventory of 1977 showed that cropland in some parts of the study area has soil erosion rates well above the national average; Tennessee cropland loses topsoil at an average rate of 14 tons per acre per year, and Alabama and Mississippi each also lose more than twice the national average of 4 tons per acre per year. In spite of increased use of Best Management Practices for soil conservation, total erosion is expected to continue to increase as more marginal and retired croplands are put into production.

5. More than 13 million acres of agricultural land were converted to urban uses in the Sunbelt since 1967. This trend will continue with the predicted acceleration of urban growth throughout much of the Sunbelt.

6. Coal mining within the study area is expected to increase, with particularly rapid development in the Texas lignite fields. Increased coal production will cause local agricultural land use changes during mining and reclamation.

- Geographic Areas

7. Depletion of ground water in the high plains will lead to crop changes (e.g., corn or sorghum to wheat) and land use changes (e.g., cropland to rangeland) in the Texas and Oklahoma Panhandles.

8. Land use conflicts are likely to be most intense along the Gulf Coast and in the Appalachian region of Kentucky and Tennessee. Coastal areas where issues are likely to be most intense include southern Florida and northern parts of the Gulf Coast, particularly those of Louisiana, the Mobile Bay area, and the north central Texas coast. In Kentucky and Tennessee, energy, forest, agriculture, wildlife, and waste disposal issues have already arisen.

9. In New Mexico complex land use issues involve strip mining of coal and uranium, and changes in irrigated agriculture, many of which are related to problems of water availability and Indian rights. Other concerns are overgrazing and erosion on fragile semiarid and arid range.

- Key Problems and Issues

10. Demands for greater agricultural production may result in drainage and clearing of land in the study area. Most of this potential cropland is now in pasture, rangeland, forest, or wetlands. Intensified management of these new croplands may increase concerns over erosion, pollution of waters by agricultural chemicals, sedimentation, and loss of natural habitat.

11. Siting of certain types of new facilities will continue to be a difficult policy issue. Controversy over the location of new energy facilities, industrial operations generating hazardous wastes, and new dumps and disposal sites, will increase in many parts of the Sunbelt. An example of such controversy is the recent debate over the new hazardous waste treatment plant in the New Orleans area.

12. Nonpoint source pollution is a significant problem for much of the study area. Eighty-seven percent of south-central and 61 percent of southeastern watershed basins are affected by agricultural nonpoint source pollution. This causes decreased land productivity, sediment accumulation in lakes, wetlands, and waterways, and pollution of waters by agricultural chemicals. Although recent policies have been developed to decrease nonpoint source pollution, increased demands for agricultural and silvicultural production will mean that this problem is likely to be magnified in the Sunbelt.

CHAPTER 12

LAND AND COASTAL ZONE USE

12.1 INTRODUCTION

The southern region is richly endowed with a diversity of environments reflecting the varied topography and climate from east to west. The region is especially rich in wetlands (coastal marshes, riverine marshes, bottomland hardwoods, etc.)--nearly half of the nation's wetlands are located in the Southeast. About one-third of the southern region is now classified as developed (urban-industrial or agricultural). Two-thirds is classified as natural ecosystems, variously affected by timbering, grazing, recreation, and other uses. A small percentage of the region is in public ownership, including national and state parks, national forests, and wildlife refuges.

Recent population and industrial growth in the southern regions together with changing agricultural patterns has contributed to many concerns about the use of these land resources. These concerns include land reclamation practices, management of farmland and forests, and protection of wildlife and wetlands. As development continues, competition among alternative land uses is likely to intensify.

The following section (12.2) describes the regulatory setting affecting land use and management issues and inventories current patterns of land and coastal zone use. Section 12.3 describes existing issues and trends related to forest, agriculture, coastal, and wetlands management. Land use concerns also include the consequences of growing industrialization, particularly mining, and the collective effects of development on wildlife and endangered species. A final section (12.4) summarizes the key land use impacts and concerns.

12.2 EXISTING CONDITIONS

12.2.1 The Regulatory System

This section summarizes federal legislation affecting land use and includes a few examples of state legislation. The various local land-use controls such as zoning ordinances administered through county or city governments are not included in this summary.

The major federal laws affecting surface uses of lands are shown in Table 12-1. Regarding the use of federal lands, this legislation requires detailed evaluation and long-term planning by the Departments of Interior and Agriculture. For state and private lands, controls on development of selected land areas are required; for example, the Coastal Zone Management Acts and the Endangered Species Acts protect some land use values and prohibit uses that could infringe on protected values. In other areas, land-use management is done cooperatively; the federal role in wildlife and agricultural development is carried out on a cooperative basis with state government agencies through the Fish and Wildlife Service and the Soil Conservation Service.

The Wilderness Acts of 1964 and 1978 and the Wild and Scenic Rivers Act of 1972 identify areas that merit preservation for their natural or aesthetic qualities. Other laws require or encourage the development of management plans for utilization of land and marine resources. The Ocean Dumping Act of 1972, the Marine Protection, Research, and Sanctuaries Act of 1972, and the Coastal Zone Management Act of 1972 were passed to enhance or maintain the quality of coastal environments and oceans.

The Coastal Zone Management Act provides a financial framework for states to develop comprehensive coastal management plans. In addition, seven states in the Sunbelt have enacted their own legislation controlling the use of their coastal areas (Table 12-2). The forest and rangeland planning and management acts require federal agencies administering the nation's forest and range lands to devise a management program that allows for multiple use. The Surface Mining Control and Reclamation Act (1977) was passed in response to the growing concern over diminishing energy reserves and the increasing reliance on surface mined coal to meet the nation's energy demands. The law restricts mining from some prime agricultural lands, requires reclamation of surface mined land, provides funds for restoration of old strip mines, and prohibits certain types of environmental degradation caused by coal extraction.

The Endangered Species Conservation Act passed in 1969 and strengthened in 1973 was designed to protect threatened and endangered species and habitat that is critical to their survival. Some states also have passed legislation regulating nonfederal activities that may affect endangered species and their habitat (Table 12-2).

Florida has one of the most comprehensive land use-control programs, based on legislation passed since 1967 (Table 12-3). Although Florida has a strong incentive to protect its natural resources which are an important asset to the state's economy,

TABLE 12-1: FEDERAL STATUTES REGULATING SURFACE USES

Federal Statutes	Jurisdiction	Selected Protective Provisions
Soil and Water Resources Conservation Act of 1977	Nationwide through Department of Agriculture (USDA)	Develops a program of soil and water quality protection
Surface Mining Control and Reclamation Act of 1977	Nationwide through Department of Interior (DOI)	Establishes reclamation standards and procedures for coal
Federal Land Policy Management Act of 1976	Public lands under Bureau of Land Management (BLM) jurisdiction	Establishes multiple use and sustained yield criteria and comprehensive planning
National Forest Management Act of 1976	National Forest and Grasslands under USDA	Requires comprehensive assessment and planning for forests and rangeland
Endangered Species Acts of 1969 and 1973	Nationwide to selected areas of critical habitat determined by the DOI	Prohibits federal development on areas identified as critical to endangered species
Coastal Zone Management Act of 1972	The coastal zone as defined by states	Establishes planning and permitting procedure for public and private coastal lands
Marine Protection, Research, and Sanctuaries Act of 1972	Nationwide marine lands, DOI	Establishes provisions for setting aside marine lands
Ocean Dumping Act of 1972	Nationwide marine environments, Department of Transportation	Controls dumping in the marine environment, prohibits disposal of specific wastes
Wild and Scenic Rivers Act of 1972	Selected stream segments protected by DOI	Identifies and preserves streams for selected recreational uses
Wilderness Acts of 1964 and 1978	Identification of public lands for limited access by DOI	Prohibits development on selected public lands
Protection of Bald and Golden Eagle Act of 1962	Nationwide protection of eagles through DOI	Prohibits destruction of eagles
Fish and Wildlife Act of 1956 (16 U.S.C. 742-754)	Nationwide cooperation with states and enforcement of U.S. Fish and Wildlife Service	Develops policies and procedures for fisheries and wildlife resources
Soil Conservation Act of 1935	Nationwide, supported by the USDA	Establishes local conservation districts and technical support

TABLE 12-2: SUMMARY OF STATE REGULATIONS PROTECTING CRITICAL HABITATS AND ENDANGERED SPECIES

Location	Tidal Wetlands	Nontidal Wetlands	Flood-plains	Endangered Species	Coastal Areas Other Than Wetlands
Region 4					
Alabama	+				+
Florida	+			+	+
Georgia	+			+	+
Kentucky			+	+	
Mississippi					
North Carolina	+		+		+
South Carolina	+			+	+
Tennessee				+	
Region 6					
Arkansas					
Louisiana					+
New Mexico				+	
Oklahoma				+	
Texas	+			+	+

+ States which have passed legislation to control use of critical habitats.

Source: Council of State Governments, 1980.

a major emphasis has been to eliminate duplication, provide coordination and avoid delay in licensing and permitting. Most of the implementation and enforcement of environmental quality and land-use laws are vested in one agency, the Florida Department of Environmental Regulation.

12.2.2 Ecosystem Types

Regions 4 and 6 include diverse environments and ecosystems, ranging from mangrove islands in Florida to eastern deciduous

TABLE 12-3: SELECTED LEGISLATION ON LAND USE AND ENVIRONMENTAL CONTROLS IN FLORIDA

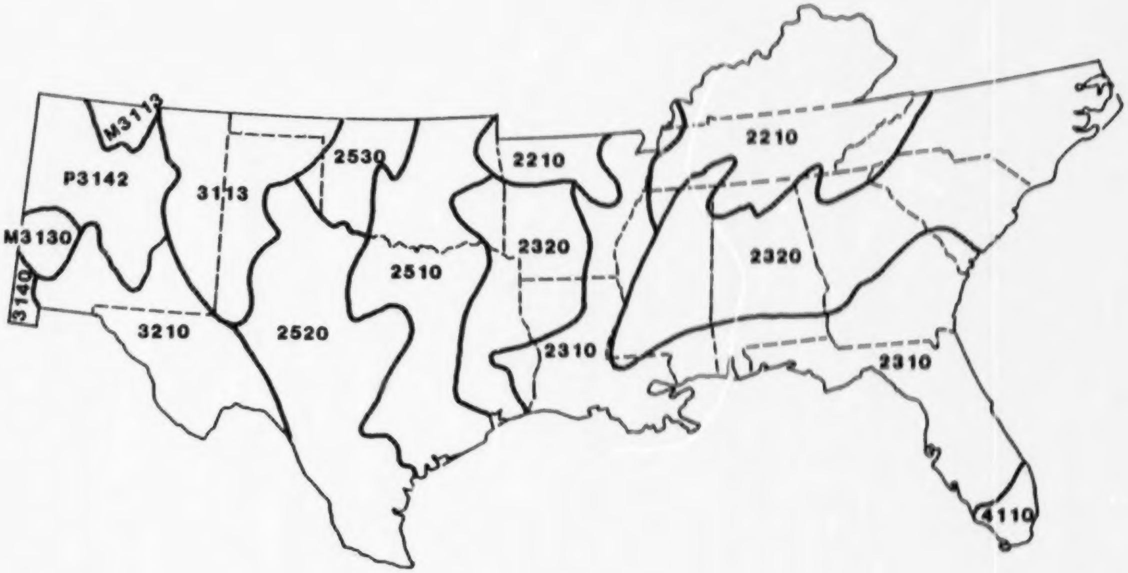
Date	Legislation
1967	Licensing requirements for the use of state lands, with special emphasis on biological features; Florida Air and Water Pollution Control Act.
1970	Establishment of Coastal Coordinating Council; Pollutant Spill Prevention and Control Act; Coastal Construction Setback Line Act.
1972	The Florida Environmental Land and Water Management Act; The Florida Water Resources Act; the Florida State Comprehensive Planning Act.
1973	Florida Electrical Power Plant Siting Act.
1974	Florida Resource Recovery and Management Act.
1975	Local Government Comprehensive Planning Act; Florida Aquatic Preserve Act.
1977	Florida Safe Drinking Water Act.
1978	Florida Coastal Management Act.
1979	Florida Industrial Siting Act.

Source: Adapted from Florida Department of Environmental Regulation, 1980.

forests and mesquite brush lands in New Mexico. Figure 12-1 shows the distribution of major natural ecosystem types, each type is described briefly in Table 12-4.

A. Forest and Rangeland

The U.S. Forest Service categorizes natural ecosystems found within the Sunbelt as either forest or rangeland. Land stocked with at least 10 percent forest trees is considered to be forest land, while land with less than 10 percent forest trees is considered to be rangeland (USDA, Forest Service, 1980).



2210	Deciduous forest
2310	Coastal plain forest
2320	Mixed forest
2510	Prairie parkland
2520	Prairie brushland
2530	Tall grass prairie
3113	Short grass prairie
M3113	Rocky Mountain forest
M3130	Upper Gila Mountain forest
3140	Mexican Highlands shrub steppe
P3142	Colorado Plateau
3210	Chihuahuan Desert
4110	Everglades

Figure 12-1: Natural Ecoregions of the Sunbelt

Source: Baily, 1978.

TABLE 12-4: MAJOR NATURAL ECOSYSTEM TYPES IN THE SOUTHERN REGION

Type	Location	Summary Description
Deciduous forest (2210)	North Arkansas, Kentucky, Tennessee, and parts of Alabama, Mississippi, and Georgia	Land is mostly rolling, except in Appalachia where local relief may be 3,000 feet. Precipitation (35 to 60 inches) is adequate all year and soils are good, having lots of humus. Much of the deciduous forest has been logged and pines have come in as secondary growth.
Coastal plain forest (2310)	The Mississippi River Valley, most of Florida, and southern Alabama, Mississippi, and Georgia	The coastal plain area is flat or gently sloping, with numerous marshes, swamps, and lakes, and receives 40 to 60 inches of rain per year. Soils are mostly wet, acidic, and low in plant nutrients. Sandy uplands have slash and loblolly pines and evergreen oaks, and bald cypress is found in wetlands.
Mixed forest (2320)	North Carolina, South Carolina, and central Mississippi, Alabama, and Georgia	The area has many marshes, swamps, lakes, and slow-moving streams. Most uplands are dominated by subclimax pine forest.
Prairie parkland (2510)	Eastern Oklahoma and Texas	A mixture of grassland and oak-hickory forest on gently rolling plains. Soils are relatively good.
Prairie brushland (2520)	Central Texas	These are arid grasslands with scattered mesquite, short oaks, and junipers.
Tall grass prairie (2530)	Central Oklahoma	These are rolling plains. In spite of the real possibility of drought, most of the area of dr is now cultivatod because soils are fertile. Thus, little of the original vegetation remains.
Short grass prairie (3113)	Eastern New Mexico, and the Oklahoma and Texas Panhandles	Soils are exposed, have a small humus content, and are often shallow.
Various (3210)	West Texas and New Mexico	A variety of ecoregions ranging from the arid Chihuahuan Desert in the South where water is extremely limited and soils are poorly developed, to the Colorado Plateau and Rocky Mountain regions at high elevations, where vegetation is controlled by altitude.
Everglades (4110)	Southern Florida	Swamps and marshes on extensive flat marl and limestone areas covered with a few feet of muck and a little sand. Some of this area is protected in the National Park, but other parts are threatened by widespread drainage and development.

Grasslands, savannas, deserts, shrublands, tundra, alpine vegetation, the coastal marshes, and wet meadows discussed in the following section are all classified as rangeland.

Rangeland and forest together account for 63 percent of the land in the southern region as compared to 69 percent in the U.S. (USDA, Forest Service, 1980). Wetlands constitute about 9 percent of the total land area in the Sunbelt, compared to about 3 percent in the entire U.S. (U.S., DOI, FWS, 1956). Little elevated (upland) rangeland exists in Region 4, but rangeland is nearly twice as extensive as forest in Region 6.

Western Texas and southern New Mexico are part of the Chihuahuan Desert, where water is extremely limited. Northwards in the Texas and Oklahoma panhandles, once vast and rolling short grass high plains, are now rangeland, wheat operations, and irrigated feed grains operations. Since the Ogallala aquifer is declining (see Chapter 13) this area may experience large changes in agricultural land use during the next few decades.

Central Oklahoma and central Texas are prairie. In Oklahoma this is very fertile wheat and rangeland. Eastern Oklahoma and eastern Texas support a mixture of prairie and oak-hickory forest, much of which is abandoned cropland.

Northern Arkansas, Kentucky, and Tennessee are characterized by rolling and hilly land which was originally covered by eastern deciduous forest, e.g., maples, hickories, oaks, and beech. Much of the deciduous forest has been logged and pines have come in as secondary growth. Large areas in private ownership have been cleared of hardwoods and converted to pine plantations for the lumber and pulp and paper industries.

A broad band of the study area, including most of Mississippi eastward and north through North Carolina, plus parts of Arkansas, Texas, and Louisiana, is uplands and coastal plains covered by southeastern mixed forest. This area was once the largest producer of cotton in the country. The region also has numerous lakes, swamps, and slow moving streams which are important wildlife habitat.

Finally, the Mississippi River Valley, most of Florida, and southern parts of adjacent states are outer coastal plain forest on flat and gently sloping wetlands and sandy uplands. This fertile land has been drained in many areas for agricultural purposes, e.g., soybeans in Arkansas, and now supports sugarcane and orchards as well as field crops.

B. Coastal Areas and Wetlands

Wetlands are highly productive ecosystems which provide habitat for many kinds of wildlife and play an important role in the hydrologic cycle. In 1956, 71 percent of the wetland acreage in the U.S. was located in the Sunbelt (Table 12-5). Wetlands constituted 15 percent of the area of Region 4 and 9 percent of the Sunbelt as a whole.[1] Half of Florida and a third of Louisiana were wetland at that time. Wetland acreages are about equally divided among coastal, riverine, and other marshes (which are classified as rangeland by the Forest Service) and swamp forests and bottomland hardwoods (also classified as forest by the Forest Service). A large percentage of southern wetlands have been converted to agricultural and other uses by draining and diking.

A comprehensive description of the coastal region of the southern states is provided in the National Estuarine Assessment conducted by the U.S. Fish and Wildlife Service (U.S., DOI, FWS, 1970). Although development has intensified since the assessment was conducted, it provides a categorization of the coastal zone as summarized below for the South Atlantic Coast, southern Florida, and Gulf Coast zones. An evaluation of the U.S. coastal zone is also being conducted by the Fish and Wildlife Service (U.S., DOI, FWS, 1979a). These estuarine wetland areas of the United States have been modified by urban, industrial, and transportation activities. The degree of modification is indicated for the three zones in Table 12-6.

1. South Atlantic Estuarine Zone[2]

This zone extends from North Carolina southward to Fort Lauderdale, Florida (Figure 12-2). Estuaries and embayments lie behind a nearly continuous barrier of islands which are typical of the South Atlantic Coast. Tidal marshes and wetlands extend inland almost the width of the coastal plain along some streams. Swamps such as Okefenokee, Dismal, and many lesser ones are located inland from the extensive tidal marshes. Pollution and land occupation have degraded a few estuaries, but most are in good condition.

A variety of estuarine-dependent fish are abundant in the South Atlantic Zone. Spotted sea trout, bluefish, striped bass, and freshwater largemouth bass are popular with sport fishermen, and shrimp, menhaden, crabs, and oysters provide large commercial

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[1] 1956 data represent the most recent completed survey. Currently the National Wetlands Inventory is providing a comprehensive update.

[2] Modified from U.S., DOI, FWS, 1970.

TABLE 12-5: WETLAND AREAS OF THE SOUTHERN REGION, 1956
(in thousands of acres)

Location	Wetland Acreage	Percent of State Acreage
Region 4		
Alabama	1,598	5
Florida	17,185	50
Georgia	5,920	16
Kentucky	273	1
Mississippi	2,589	9
North Carolina	4,055	13
South Carolina	3,377	18
Tennessee	828	3
Total	35,825	15
Region 6		
Arkansas	3,785	11
Louisiana	9,647	34
New Mexico	49	<1
Oklahoma	280	<1
Texas	3,741	2
Total	17,502	5
Sunbelt	53,327	9
Northeast	1,674	1
U.S.	74,439	3

Source: U.S., DOI, FWS, 1956.

yields. Waterfowl, shorebirds, and marsh birds of many northern U.S. (and Canadian) species winter in the expanses of wetlands in this zone.

The South Atlantic Zone is well known for its warm, moist climate due to its proximity to the Gulf Stream. The extensive beaches from Florida to North Carolina are valued for their recreational qualities.

TABLE 12-6: COASTAL ZONE MODIFICATION

	Degree of Modification[a] (percent)		
Biogeographic Zone[b]	Slight	Moderate	Severe
South Atlantic	36	60	4
Biscayne and Florida Bay	50	50	0
Gulf of Mexico	15	51	34
United States	27	50	23

Source: Field evaluation carried out by Fish and Wildlife Service personnel during course of Estuary Protection Act study (U.S., DOI, FWS, 1970).

[a] Estuaries in the coastal zone were individually rated. The percentage refers to the proportion of these individual areas that were rated as indicated by the U.S. Fish and Wildlife Service. The rating represents a summary of the degree of use and impact by 15 major use categories and 17 impact categories. The 15 major use categories are:

- Agriculture & forestry
- Commercial fishing
- Defense
- Fish & wildlife conservation & management
- Industry
- Mining (including oil)
- Pest control
- Power production
- Recreation
- Research & education
- Sanctuaries
- Transportation
- Urbanization
- Waste disposal
- Water supply (including ground water)

Seventeen major impact sources were rated as to their severity of impact on fish, wildlife, recreation, and aesthetic values. These major impact sources are:

- Oil pollution
- Thermal pollution
- Sewage pollution
- Industrial waste
- Agricultural waste
- Pesticide pollution
- Solid waste disposal
- Divert tributary freshwater
- Modify tidal exchange
- Mining
- Channel dredging & spoiling
- Bulkhead, dredge & fill
- Seawalls, dikes & levees
- Saltwater barriers
- Coastal freshwater storage
- Ditch & drain wetlands
- River control

[b] Also see the maps and description of each zone that follow.

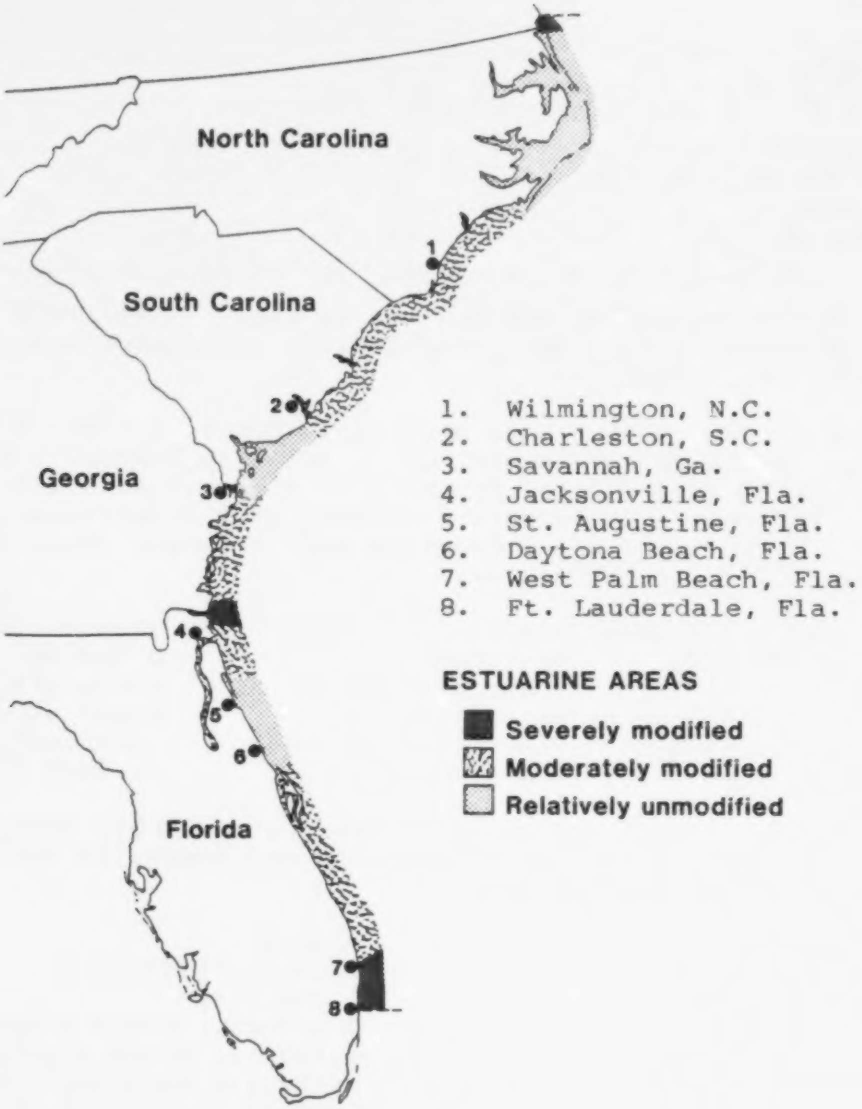

Figure 12-2: South Atlantic Coastal Area

Source: U.S., DOI, FWS, 1970 p. 36.

2. Biscayne and Florida Bay Estuarine Zone[1]

This small zone extends from Fort Lauderdale around the tip of Florida inside the Florida Keys to Cape Romano (Figure 12-3). It includes Biscayne Bay, the western edge of the Everglades, and the Keys. The entire coast is barely above sea level. The zone is enclosed by the Keys on the east and south and is mainly within the Everglades National Park.

Coral reefs and mangrove swamps are common. Seasonal and long-term droughts and tropical storms cause occasional stresses. Municipal water use has intensified droughts, and discharges to receiving waters and wetland occupation have modified some areas.

This zone is the nursery of a large and important shrimp fishery. It also is highly productive of many important finfish, including tarpon, snook, spotted sea trout, pompano, and others, as well as crabs and spiny lobster. Oysters grow on the roots of the zone's abundant mangrove forest. Like other coastal areas, this zone is occupied by several rare and endangered species. For example, the Florida great white heron, Florida manatee (sea cow), southern bald eagle, Caribbean monk seal, Cape Sable sparrow, Key deer, and other species are on the endangered species list. The aesthetic attractions of the zone are known widely including the coral reef underwater gardens.

3. Gulf of Mexico Estuarine Zone[1]

This zone extends around the Gulf Coast from Cape Romano in southwest Florida to the Texas-Mexico border near Brownsville (Figure 12-3). The entire zone borders a wide coastal plain of generally low relief. The dominant and unique estuarine feature is the Mississippi River Delta with its vast area and network of channels and bayous. Notable also are the industrialized Tampa, Mobile, and Galveston bays; the elongated complex of bays, marshes, and islands of the eastern Texas coast; and the long estuaries and barrier islands of the Florida, Alabama, Mississippi, and Texas coasts. The western estuaries experience droughts, and the entire zone is subject to hurricanes on occasion. Many estuaries of the zone have been modified by petrochemical and industrial developments, drainage of wetlands, and diversion of runoff. However, the Gulf Coast is highly productive of a great variety of estuarine dependent fish and shellfish, notably red snapper, spotted sea trout, menhaden, shrimp, crabs, and oysters.

Birds are a major resource of the Gulf Coast. Waterfowl, the endangered whooping crane, and other birds of the Central,

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[1] Modified from U.S., DOI, FWS, 1970.

1. Corpus Christi, Tex.
2. Houston, Tex.
3. Galveston, Tex
4. Port Arthur, Tex.
5. Lake Charles, La.
6. New Orleans, La.
7. Gulfport, Miss.
8. Biloxi, Miss.
9. Mobile, Ala.
10. Pensacola, Fla.
11. Tampa, Fla.
12. St. Petersburg, Fla.
13. Sarasota, Fla.
14. Ft. Myers, Fla.

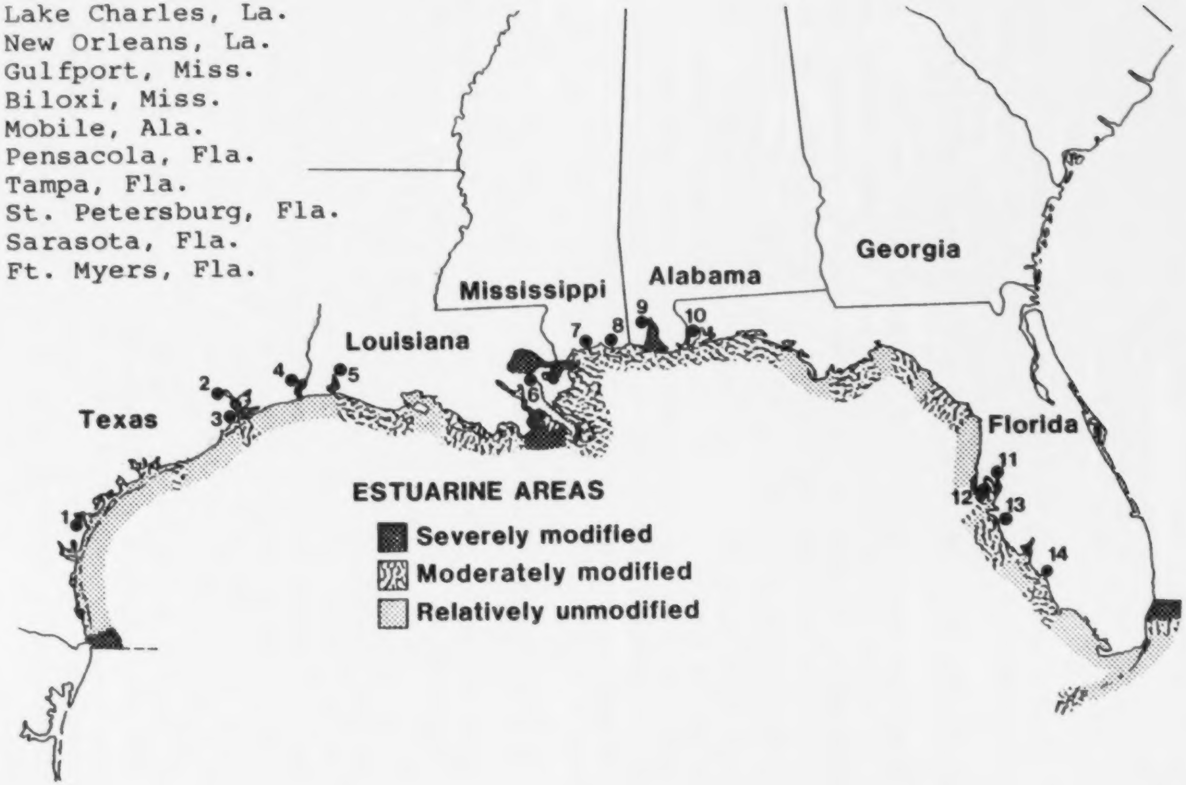

Figure 12-3: Gulf Coast and South Florida Coastal Areas

Source: U.S., DOI, FWS, 1970, p. 40

Mississippi, and Atlantic flyways, all winter in the extensive and rich marshes and estuaries of the Gulf Coast. Thus, habitat destruction will affect not only wildlife of coastal areas, but also populations that spend a great part of their lives elsewhere.

12.2.3 Current Status of Land Use

Approximately 38 percent of the southern region is forest land, ranging from 14 percent in Texas to 67 percent in Georgia. Thirty-two percent of the region is pasture and rangeland, ranging from 3 percent in South Carolina to 65 percent in New Mexico. About 20 percent is in cropland, ranging from 3 percent in New Mexico to 37 percent in Kentucky. Urban areas account for a relatively small proportion of total land area, about 2 percent of the study area, ranging from less than 1 percent in New Mexico to 6 percent in Florida. Within regions 4 and 6, about 3 percent of the land is classified as marshes, swamps, rocky areas, or deserts not associated with any particular land use type; the amount of land in this category varies from a low of 1 percent in Oklahoma to 12 percent in Louisiana.

A breakdown of land use patterns reveals several major geographical differences in the utilization of land resources. As shown in Figure 12-4, roughly similar percentages of total land area are devoted to cropland and pastureland in both regions of the Sunbelt and the total U.S. However, the Sunbelt has more pastureland than the U.S. average, Region 4 has considerably more nonfederal rangeland, and Region 6 has considerably more nonfederal forestland. Although the majority of commercial forest in the Sunbelt is in nonindustrial private ownership, the leasing of large tracts by lumber and paper companies is becoming more common in Region 4 (USDA, Forest Service, 1980) (see chapters 9 and 10). Nearly twice the percentage of land in Region 4 has undergone urbanization than in Region 6. As population levels continue to increase throughout the next several decades, this particular use of the land can be expected to expand in areal extent.

12.3 TRENDS AND ISSUES

12.3.1 Key Driving Forces

A. Population and Industrial Growth

As indicated in Chapter 3, the southern states are projected to have 83.9 million people by the year 2010, a gain of 20.7 million. This would represent a 31 percent population increase in the Sunbelt, compared to a 21 percent increase projected for the U.S.

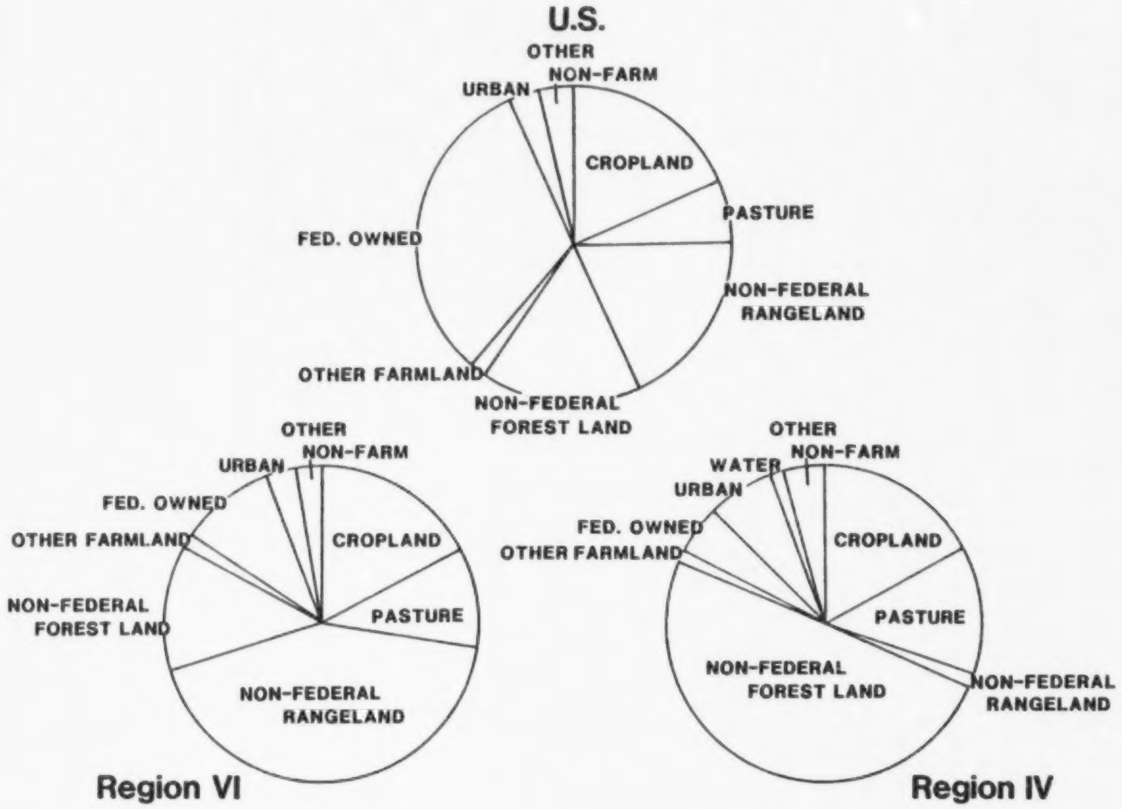

Figure 12-4: Land Use Patterns in the U.S. and the Sunbelt

Source: Hidlebaugh, 1980.

The Sunbelt is the only part of the country characterized by a faster growth rate in metropolitan areas than in nonmetropolitan areas. Many of the major cities in the Sunbelt have strong economies and relatively low unemployment. This growth and prosperity have increased the demand placed on natural ecosystems for recreation and the supply of resources. The expansion of urban areas has caused the loss of both prime agricultural land and natural habitats (Vining, Plaut, and Bieri, 1977). Projections for future population trends (see Chapter 3) suggest that these problems will intensify in years to come.

Population increases related to industrial and municipal growth will contribute to the construction of new roads, installation of power and gas lines, and other developments that are part of the urbanization process. The modification of wetland habitats by urban expansion has been a major development in areas adjacent to waterways and the coast. It is estimated that the area of wetlands in the U.S. at one time totaled 127 million acres. During the westward expansion of the U.S., most wetlands were removed from the public domain and given to the states to use as they believed appropriate. Subsequently, many wetlands came under private ownership for a variety of uses. Draining and filling of these habitats over the last two centuries has reduced wetland acreage to approximately 70 million acres (USDA, Forest Service, 1980). Coastal wetlands in the Southeast in particular have undergone recent reduction through both drainage and conversion to agricultural land and inundation to form reservoirs.

Much of wetlands modification has accompanied major transportation projects such as the Intercoastal Waterway and navigation projects such as the Tennessee-Tombigbee Waterway. Contributing to these transportation and industrial developments has been the growth in international trade, especially in raw materials (wood, coal), agricultural commodities, and chemicals and finished products from the southern states and from inland areas.

B. Forest Clearing and Agricultural Development

From 1920 to 1960 the nation's commercial timberlands expanded (see Chapter 9). Much of the increase in forest occurred in the South where erosion and depletion of soil fertility led to the abandonment of cottonlands and the subsequent reversion to forest (USDA, 1975; USDA, Forest Service, 1980). In the last two decades, however, that trend has reversed with the conversion of some forest land to agricultural land. For example, parts of the coastal plain forests in North Carolina are being cleared for agriculture and this area is likely to receive much pressure for clearing in the near future (USDA, Forest Service, 1980).

The reduction of commercial forest has been most dramatic in the South and in the Rocky Mountain states. For the South, the

U.S. Forest Service predicts that during the 1980's clearing for cropland will be responsible for most of the forest loss. As cities expand in adjacent rural areas, the lost farmland is replaced by additional clearing. After 1990 most forest reduction may likely be the direct result of clearing for urban facilities, creation of reservoirs, and the removal of mineral resources (USDA, Forest Service, 1980).

Bottomland forest habitat has undergone a more dramatic reduction than other forest types, declining 20 percent in acreage from 1962 to 1970 (USDA, Forest Service, 1980). The Mississippi River Valley is one of the most productive forest areas in the southern region and this land is rapidly undergoing conversion to agricultural land, primarily for the production of soybeans. Inundation by new reservoirs and harvesting by the timber industry have also diminished bottomland forests.

The creation of pastureland in the South primarily reduces upland forest acreage. The Forest Service predicts that the nation's biggest increase in demand for grazing land over the next 50 years will occur in the South (USDA, Forest Service, 1980), which may contribute to a further reduction in forests.

C. Recreational Activities

The increase in mobility and leisure time in the American society has led to increases in recreational use of the nation's waterways and natural lands. Recreational activities conducted outdoors in natural environments include boating, swimming, picnicking, hiking, camping, off-road vehicle use, hunting, fishing, and skiing. In 1977, Forest Service holdings provided for 90 percent of the recreational use of federal lands (USDA, Forest Service 1980). Utilization of the national forests for recreation increased 37 percent from 1967 to 1977. Visitation in the National Park System has undergone an even greater growth, with an increase from 33 million to 217 million annual visitors from 1950 to 1974 (USDA, 1975). Growth of the land areas of the system accompanied the increase in national park use, although at a slower rate. The Appalachian National Scenic Trail experienced a 35 percent increase in use between 1974 and 1976 (USDA, Forest Service, 1980).

There has recently been a substantial increase in the use of wilderness and other dispersed areas--a trend which has accompanied growth in the popularity of backpacking in the last decade (USDA, 1975). Sixty percent of all visitor use in national forests now occurs in these dispersed areas. The use of wilderness areas is expected to increase 80 percent by 2020 (USDA, 1975). The Forest Service anticipates a 90 percent growth in the demand for both backcountry and developed camping facilities by the year 2020, (USDA, 1975).

The Forest Service has predicted a greater growth in demand for outdoor recreational facilities in the southeastern U.S. and southern Rocky Mountains (including New Mexico) than for the nation as a whole (USDA, Forest Service, 1980). In part, this growth is due to the population increases described in Chapter 3. Yet, the majority of the nation's preserved lands and recreational facilities are in the western U.S. The federal government expenditure per capita for recreation is greater in the western states than in either the North or the South (USDA, Forest Service, 1980). The few recreational facilities located close to cities experience a great deal of use. Lumber companies in the southern region which lease hunting and fishing rights to their property have helped alleviate this pressure. Some companies have agreements with state wildlife or natural resource departments for developing game management plans on their land (USDA, Forest Service, 1980).

As the growing demand for recreational facilities intensifies use of existing land preserves, conflicts among various user groups are likely to become more common. Some recreational activities are more damaging to natural areas than others. Activities which are growing most rapidly in popularity are among those which are potentially destructive to delicate habitats unless managed effectively, such as off-road vehicle use, snowmobiling, and motorcycling. The use of off-road vehicles is expected to increase 70 percent by 2020 (USDA, 1975). Beyond a certain point recreational use of natural lands causes habitat degradation, rendering the land unsuitable for certain types of wildlife and reducing aesthetic qualities for which some of the preserves were set aside. Some ecosystems, such as wetlands, coastal environments, and tundra, are more fragile than others.

D. Energy and Resource Development

Increased population and uncertain foreign energy supplies have caused an increased demand for fossil energy resources, many of which underlie southern lands (see Chapter 6). Tennessee, Kentucky, and Alabama currently constitute the major coal producing states within the Sunbelt (USDA, Forest Service, 1980). Coal mining is projected to double in the southern region, from about 200 million tons per year in 1977 to 400 million tons per year by the year 2000 (see Chapter 6). The use of surface mining for coal removal is expected to increase significantly in the future (USDA, Forest Service, 1980). Much of the southern region also contains major supplies of petroleum and natural gas (Chapter 6). Production of these resources in Texas and Louisiana has increased sevenfold since 1950 in terms of dollar value (USDA, Forest Service, 1980). Exploration activities in Oklahoma and Texas have tripled since 1978 as indicated by drilling rig activity.

The Sunbelt also contains 42 percent of the known phosphate reserves in the country (USDA, 1975). These are located primarily in the coastal plain areas of Florida and North Carolina. An extensive area of Florida has been altered by phosphate mining, and mining operations have recently begun in North Carolina's phosphate deposits. The demand for phosphate is expected to increase in the future.

E. Summary of Driving Forces

Increases in population, industrial, forest, and agricultural use of available natural and land resources in the southern region are expected to intensify. Increased recreational use in limited natural preserves is likely to affect wildlife habitat and wilderness areas. Growing demand for energy resources, phosphates for fertilizers and other products, and other minerals may intrude upon some natural habitats. Urban sprawl and the need to replace lost agricultural land may also contribute to the underlying driving forces affecting land and coastal zone use.

12.3.2 Problems of Protecting Natural Ecosystems

In the Sunbelt, there are only limited natural ecosystems which are in public ownership or otherwise "protected"--that is, designated to remain in a natural or managed seminatural state. Nationwide, the federal government administers 54 percent of the rangeland and 39 percent of the forestland. A much smaller percentage of land is government owned in the Sunbelt--less than 15 percent of the range and forest resources (USDA, Forest Service, 1980). Most of the remainder is privately owned. The total forested land in the Sunbelt, 221 million acres, is about 30 percent of the U.S. total. Of this, 195 million acres are held privately and are considered "unprotected" (Table 12-7). Most of the remaining acreage is administered by the Forest Service, primarily in New Mexico and Arkansas. Of the 153 million acres of rangeland, about 12 million acres are in public ownership, almost exclusively in New Mexico (Table 12-8). New Mexico has the greatest proportion of rangeland, about 63 percent. Texas and Oklahoma also have large areas of rangeland, primarily used for valuable livestock purposes.

The degree of protection given to a particular land unit depends on the managing federal agency. Most of the federally owned forest and rangeland is administered by the Forest Service as shown in Table 12-9. Management programs practiced by this agency promote the use of land resources for a variety of recreational and commercial purposes, including timber products, water resources, forage for livestock, wildlife habitat, and mineral resources.

TABLE 12-7: FORESTLAND OF THE SUNBELT BY OWNERSHIP AND MANAGEMENT AGENCY, 1977

(thousands of acres)

Location	Total Forested Land	Percent of Area Forested	Forest Service	Bureau of Land Management	Other Federal Agencies	Non-federal Forested Land
Region 4						
Alabama	21,361	66	640	0	199	20,521
Florida	17,040	49	1,082	0	1,237	14,721
Georgia	25,256	70	856	0	642	23,757
Kentucky	12,161	48	656	0	280	11,225
Mississippi	16,912	56	1,138	0	160	15,614
North Carolina	20,043	64	1,146	0	679	18,218
South Carolina	12,249	63	607	0	149	11,493
Tennessee	13,161	50	620	0	441	12,099
Total	188,183	58	6,746	0	3,789	127,649
Region 6						
Arkansas	18,281	55	2,465	0	196	15,620
Louisiana	14,558	51	596	0	144	13,818
New Mexico	18,060	23	7,851	2,015	693	7,501
Oklahoma	8,513	19	224	0	99	8,190
Texas	23,279	14	615	0	192	22,473
Total	82,692	24	11,751	2,015	1,325	67,602
Sunbelt	220,875	38	18,496	2,015	5,113	195,251
U.S.	740,143	33	141,864	114,163	29,130	454,985

Source: USDA, Forest Service, 1977, Table 2.3.

TABLE 12-8: RANGELAND OF THE SUNBELT BY OWNERSHIP AND MANAGEMENT AGENCY, 1977 (thousands of acres)

Location	Total Range land	Percent of Area in Range-land	Forest Service	Bureau of Land Manage-ment	Other Federal Agencies	Non-federal Range-land
Region 4						
Alabama	54	<1	0	0	1	53
Florida	2,189	6	0	0	197	1,992
Georgia	0		0	0	0	0
Kentucky	0		0	0	0	0
Mississippi	20	<1	0	0	9	11
North Carolina	0		0	0	0	0
South Carolina	20	<1	0	0	0	20
Tennessee	400	2	0	0	4	400
Total	2,683	1	0	0	208	2,475
Region 6						
Arkansas	0	0	0	0	0	0
Louisiana	517	2	0	0		517
New Mexico	48,725	63	1,394	10,942	2,776	33,614
Oklahoma	9,301	21	67	8	120	9,107
Texas	91,599	55	166	0	1,147	90,285
Total	150,142	43	1,627	10,950	4,042	133,523
Sunbelt	152,825	26	1,627	10,950	5,449	135,999
U.S.	820,087	36	45,037	346,005	47,775	381,269

Source: USDA, Forest Service 1977, Table 2.3.

The majority of the remaining federal range and forest land is managed by the National Park Service, the Fish and Wildlife Service, and the Department of Defense. The National Park Service manages 3.8 million acres in the southern region, primarily in Florida and Texas (Table 12-9). The primary task of the National Park Service is to preserve land units which are of natural, historical, recreational, or cultural value. On most of the National Park Service lands grazing, mining, hunting, and timber harvesting are prohibited. The U.S. Fish and Wildlife Service is responsible for managing most federal wildlife refuges, comprising about 1.2 million acres in the southern region. Preserving wildlife habitat is the basis for establishing most refuges, although the Fish and Wildlife Service permits other activities, such as hunting and fishing, as long as they do not threaten populations of organisms the refuges were designed to protect.

In addition to these broader classes of land reserves, the agencies identified above manage 2.17 million acres for the primary purpose of preserving the land's wilderness qualities. These wilderness areas generally receive less intense use than the national parks and monuments. Currently, grazing and mining are permitted in some wilderness areas, but no new mining claims can be filed after 1983. Few operative mines exist in wilderness areas due to their inaccessibility. Timber harvest is prohibited on these tracts; and in some areas recreational use is limited so that alteration of the landscape is minimized. A continuing issue is whether additional lands should be set aside to protect natural areas, or whether existing protected areas should be more accessible to development.

12.3.3 Problems and Issues in Agricultural Development

Agricultural lands are confronted with a range of problems, including demands for increased agricultural production, by changes in technologies and land management practices, and competition from other land uses. These problems include ecological problems associated with monoculture such as pesticide use, erosion and sedimentation, prime farm land loss, and land treatment of wastes. These issues are discussed in the following sections.

A. Pesticide Uses

Pesticides include both herbicides and insecticides. Although more attention has been given to insecticide use and the associated ecological and health issues, herbicides are also widely used. Approximately 86 million pounds of insecticides were used in the South in 1976, about two-thirds of the U.S. total. Ninety-eight million pounds of herbicides were used in 1976, representing 26 percent of the nationwide total (see Chapter 9). Application of many insecticides has not increased since

TABLE 12-9: PROTECTED ACREAGE WITHIN THE SOUTHERN REGION (thousands of acres)

Location	National Park Service Holdings[a]	Wilderness Areas[b]	National Forests[c]	National Wildlife Refuges[c]	Nataure Conservancy Sanctuary[d]	State Parks & Recreation Areas[e]	NERP[f]	Private Hunting Plantations[g]	Total "Protected" Land
Region 4									
Alabama	6	13	1,263	48		48	0	150	1,527
Florida	1,750	1,322	1,224	451	12.10	286	0	243	5,287
Georgia	31	32	1,911	465	0.75	52	0	475	2,967
Kentucky	62	5	1,415	2	0.23	42	0	0	1,526
Mississippi	101	0	2,310	103	0.03	20	0	75	2,608
North Carolina	358	31	2,953	124	2.57	116	0	33	3,618
South Carolina	6	3	1,380	142	3.42	66	300	125	2,025
Tennessee	261	8	1,204	82	0.19	139	200	0	1,894
Total	2,575	1,414	13,661	1,418	19.31	768	500	1,101	21,456
Region 6									
Arkansas	80	35	3,488	193		422	0	33	4,251
Louisiana	34	0	1,022	276		30	0	33	1,395
New Mexico	247	671	10,125	375		71	0	0	11,490
Oklahoma	2	0	413	141	0.09	90	0	0	646
Texas	958	47	1,730	210	0.60	132	0	0	3,077
Total	1,321	754	16,780	1,194	0.69	746	0	66	20,861
Sunbelt	3,896	2,168	30,440	2,613	20.00	1,513	0	0	42,318
U.S.	26,531	8,392	220,057	34,947	NA	9,417	NA	NA	NA

NA = not applicable

[a] U.S., DOI, BLM, 1978.

[b] U.S., DOI, National Park Service, 1979; USDA, Forest Service, 1979.

[c] USDA, Forest Service, 1979.

[d] Nature Conservancy, 1975.

[e] Council of State Governments, 1980.

[f] National Environmental Research Parks at Federal National Laboratories.

[g] Komerek, 1981; acreages for some states are estimated; similar preserves may exist in the western part of Region 6, but those figures are not included herein.

1970, but herbicide use has increased a great deal. Residues have appeared in water supplies adjacent to agricultural land and abandoned dump sites in localities throughout the southern region (U.S., CEQ, 1980). Pesticides accumulate in the food chain, posing threats to wildlife as well as humans by affecting the central nervous system, the reproductive system, or by carcinogenic and mutagenic properties.

The EPA has primary responsibility for pesticide regulation under the Federal Insecticide, Fungicide, and Rodenticide Act, but the thousands of compounds on the market make analysis of these chemicals very difficult; nevertheless, several pesticides once widely used in the South have been banned (e.g., DDT) or limited in usage (2,4,5-T).

Monitoring studies on pesticides have mostly focused on the organochlorine group of insecticides that tend to affect ecosystems through accumulation and magnification, but herbicides and fungicides are more likely to affect the lower level of food chains (Crosson and Brubaker, 1981). Little is known about what happens to pesticides after they leave the fields or about the ability of ecosystems to recover from temporary high concentrations of a pesticide. The organochlorine insecticides tend to persist (for three to six years) and increasingly concentrate in the body tissue of higher animals. In high enough dosages, tests have shown some organochlorines to be carcinogenic or teratogenic. DDT was banned in 1972; by 1976 the only organochlorine still used in large quantities was toxaphene. The organophosphorus and carbamate compounds that replaced the organochlorines are not as persistent (only 1 to 3 months) and do not accumulate, but most are highly toxic to humans and other organisms, their damage is sharp, localized, and short-term (e.g., industrial accidents).

Insects can build genetic resistance to some insecticides and new generations of insecticides are used to increase effectiveness. Even Integrated Pest Management (IPM) makes use of chemical pest control, thus, any pesticide safety program is likely to have risks associated with it.

Most herbicides have low toxicity to humans, except paraquat (used on conservation tillage) which is highly toxic and can cause skin irritations even in dilute form. Others, such as 2-4-D are suspected of being carcinogenic and may produce birth defects and miscarriages as well. Atrazine used on corn and sorghum (see Chapter 9) has low toxicity to humans but in the human stomach may be carcinogenic. Fungi and microorganisms metabolize propanil to a compound similar to 2,4,5-T, which has been restricted. The effects of pesticides on soil microorganisms and on water organisms is largely unknown.

In the Sunbelt from 1974 to 1976, 1,307 incidents of pesticides poisoning resulting in hospitalization of both workers and the public were reported. Region 4 experienced most of these incidents (85 percent)--this was nearly double any other region in the country. Region 6 ranked third nationally during this period. Most pesticide poisonings were nonoccupational, unintentional, and not related to specific characteristics of the southern region. Occupational exposure to pesticide poisoning accounted for about one-fourth the hospitalizations, mostly of farmers and commercial applicators.

Residues of some pesticides appear to have declined slightly in agricultural soils (Table 12-10), and pesticide use may decline if IPM techniques spread. However, increases might be expected in some areas as demands for cropland increase and as other crop production causes more land presently in unmanaged forest and rangeland to be converted to intensively managed cropland. In addition, as low-till and no-till agricultural practices expand, herbicide use on those lands will increase since chemical weed control will be substituted for the mechanical control provided by plowing.

Pesticides runoff and contamination of surface water is the major toxic water quality problem in much of Texas, Louisiana, Arkansas and Mississippi (U.S., CEQ, 1980). However, some improvement in water quality has occurred as levels of persistent pesticides have diminished due to restrictions on the use of some chlorinated hydrocarbons, such as DDT (see chapters 9 and 14).

B. Erosion and Sedimentation

As discussed in Chapter 9, agricultural lands in the South have experienced large and rapid rates of erosion. Sediment from soil erosion is the major nonpoint source water pollutant, and cropland alone produces about 40 percent of the total sediment in inland waterways nationwide (U.S., EPA, ORD, 1980, p. 355). Sixty-eight percent of all U.S. basins are affected by agricultural nonpoint source pollution. Within the study area, it is estimated that 87 percent of southcentral and 62 percent of southeastern basins are so affected (U.S., CEQ, 1979b, p. 149) (see Chapter 9).

Direct impacts of this erosion are: (1) loss of topsoil with decline in land capability and consequent decreases in productivity (if productivity decreases are substantial, uses may become more limited); (2) deposition of sediment in, and clogging of, wetlands, lakes, and waterways (often leading to dredging and fill operations which cause further ecological disruption); and (3) runoff of pesticides, herbicides, and fertilizers into adjacent waters. If the Southeast does become an area of greatly

TABLE 12-10: PESTICIDE RESIDUES IN AGRICULTURAL SOILS,[a] 1969-1974[b]
(ppm dry weight, geometric mean)

Pesticide	1969	1970	1972	1973	1974
DDT[c]	.0148	.0125	.0131	.0100	.0073
Aldrin	.0031	.0034	.0024	.0021	.0008
Dieldrin	.0088	.0104	.0097	.0090	.0066
Aldrin/dieldrin	.0119	.0138	.0121	.0111	.0074
Toxaphene	.0025	.0011	.0045	.0035	.0017
Chlordane	.0038	.0046	.0035	.0034	.0006
Heptachlor	.0008	.0013	.0010	.0006	.0003
Heptachlor epoxide	.0014	.0017	.0010	.0012	.0010

ppm = parts per million

Source: Adapted from U.S., CEQ, 1979a, p. 128.

[a] Data were collected from 34 states, except that for 1972. Heptachlor and heptachlor epoxide data were collected from 37 states.

[b] Not measured in 1971.

[c] DDT includes DDT and its related derivatives.

expanded production of crops as projected by BEA data (see chapters 4 and 9), erosion will increase above current amounts.

The amount of soil loss that may occur without concomitant losses in soil productivity can be expressed by the average soil loss "Tolerance" for various land uses. Although soil properties, climate, and topography differ greatly from one area to another, an average Tolerance value for cropland, pasture, and forestland is about 4 to 5 tons per acre per year (this is equivalent to the loss of one-thirtieth of an inch per acre). Because rangeland is generally much more fragile, its Tolerance value is only 2 tons per acre per year. The heaviest erosion is typically seen on soils that contain a large percentage of silt, that are located on steep or long slopes, or are in areas with frequent and intense rainfall. Land use also affects the rates of erosion, with cropland experiencing much worse erosion than pasture or forest (Table 12-11).

TABLE 12-11: REPRESENTATIVE EROSION RATES WITH VARIOUS LAND USES

Land Use	Tons Per Acre Per Year	Approximate Value Relative to Forest = 1
Forest	0.04	1
Grassland	0.4	10
Abandoned Surface Mines	3.8	100
Cropland	7.5	200
Harvest Forest	19.0	500
Active Surface Mines	75.0	2,000
Construction	75.0	2,000

Source: Modified from Conner, Travis and Trudeau, 1980.

There are four basic types of erosion: wind erosion; sheet and rill erosion which is caused by the movement of water across the soil; gully erosion that involves the formation or enlargement of ravines or chanels; and streambank erosion. Information has been collected on sheet and rill erosion throughout the country and on wind erosion only in the Plains states.

Except for the Southern Plains and Mountain regions, sheet and rill erosion causes by far the most damage--two-thirds of the total 6.8 tons per acre lost in the U.S. (Table 12-12). In the South, the Appalachian, Delta, and Southeast regions[1] experience the highest sheet and rill erosion, while the Southern Plains states are subject to significantly high wind erosion (averaging over 11 tons per acre per day). The U.S. as a whole plus all the regions containing Sunbelt states exceed the average Tolerance erosion rate of 5 tons per acre per year.

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[1] The Appalachian region includes the states of Kentucky, North Carolina, and Tennessee; the Delta region, Louisiana, Mississippi, and Arkansas; the Southeast region, Alabama, Georgia, Florida, and South Carolina; and the Southern Plains, the states of Oklahoma and Texas (see Chapter 9).

TABLE 12-12: EROSION FROM CROPLAND IN THE U.S., 1977

Region and Example State	Wind		Sheet and Rill		Total		Percent of National Total	
	Amount (millions of tons)	Tons Per Acre	Amount (millions of tons)	Tons Per Acre	Amount (millions of tons)	Tons Per Acre	Erosion (weight)	Cropland (area)
Appalachian	ne		186.3	9.0	186.3	9.0	6.7	5.0
Tennessee	ne		69.5	14.1	69.5	14.1	2.5	1.2
Southeast	ne		111.0	6.3	111.0	6.3	4.0	4.2
Georgia	ne		42.7	6.6	42.7	6.6	1.5	1.6
Delta	ne		154.9	7.3	154.9	7.3	5.5	5.1
Arkansas	ne		46.7	5.9	46.7	5.9	1.7	1.9
Southern Plains	488.8	11.6	141.4	3.4	630.2	15.0	22.5	10.2
Texas	453.5	14.9	99.5	3.3	553.0	18.2	19.6	7.4
Mountain	190.3	4.5	70.8	1.7	261.1	6.2	9.3	10.2
Nation	891.0	2.1	1,908.0	4.7	2,799.0	6.8	100.0	100.0

ne = not estimated.

Source: Crosson and Brubaker, 1981.

Soil loss from all sources of water erosion are higher than average in the Sunbelt, based on estimates from climate, slope, and soil characteristics, and common cropping practices. Twenty-two of 50 states have average annual cropland water-induced erosion rates of 4 tons or more per acre; 10 of those are in the 13-state study area (USDA, SCS, 1978). Table 12-13 suggests that cropland in certain parts of the study area has erosion rates well above the national average. In fact, the 1977 inventory suggests that even some nearly level wet soils in the Mississippi Delta region are eroding at above permissible rates, i.e., faster than they can develop naturally (USDA, SCS, 1978, p. 4).

The Soil Conservation Service encourages the use of best management practices to reduce soil loss and improve water quality. Since erosion removes only a thin layer of soil each year and productivity losses appear gradually, few incentives may exist to use protective measures. The problem is compounded since average annual net capital investment in both soil conservation and watershed protection measures has declined each year since 1970 (Timmons, 1979, p. 65). Erosion will probably continue to increase in the study area in the future if a greater use of marginal cropland and conversion from other uses occurs.

C. Loss of Prime Agricultural and Forest Land

As population and industrial development increase, land is converted from agricultural and forest uses to the production of housing, transportation facilities, and other urban-related uses. Over 10 million acres in Region 4, and 3 million acres in Region 6 were converted to urban, built-up, transportation, and water uses between 1967 and 1977 (Table 12-14). This represents over 40 percent of all U.S. land converted during that period. Florida, Texas, North Carolina, and Georgia had the most acres converted.

Land conversion creates several potential problems. If the converted land is valuable agricultural or forest land, U.S. agricultural and forest productivity can be reduced at a time when U.S. farm and forest exports contribute to the world food, feed, and fiber supply and to the U.S. balance of payments. About 32 percent of all land converted in the study area was prime farmland (Lee, n.d., p. 14). Another 40 percent consisted of land that is currently or is potential cropland. Because cities generally developed in areas of good soils, urban growth tends to selectively convert the best farmland. Only about 20 percent of all land in the South is prime farmland, yet almost a third of the land actually converted was prime farmland (Diderikson _et al_., 1977, pp. 57-71).

TABLE 12-13: CROPLAND SOIL EROSION DUE TO WATER AND WIND, 1977

State/Area	Water[a] (tons/acre/year)	Wind (tons/acre/year)
Alabama	9.90	
Arkansas	6.48	
Florida	4.17	
Georgia	6.58	
Kentucky	9.40	
Louisiana	7.90	
Mississippi	10.92	
New Mexico	2.00	11.49
North Carolina	7.64	
Oklahoma	3.68	2.97
South Carolina	4.77	
Tennessee	14.12	
Texas	3.47	14.92
U.S. Average	4.77	

Source: U.S., CEQ, 1979b.

[a] Includes sheet and rill, gully, and streambank erorison.

D. Changes to Grasslands and Forests

Agricultural practices described in Chapter 9 (Agricultural Development and Forest Management) have resulted in a replacement of diverse natural ecosystems with monocultures (single crops) that provide a high yield. Two types of ecosystems have been replaced in many localities of the southern region: native grasslands and hardwood forests. Some of the native grassland types, such as the tall grass prairie that occurred in Oklahoma and Texas, have largely been replaced by forage crops and intensively grazed rangeland. The native grasslands once supported a wide range of animal species and mediated against erosion. Small areas of tall grass prairie have been preserved, but the maintenance of biologically diverse grasslands is difficult under conditions where strong incentives and pressures exist to increase agricultural yields.

Forests have also experienced major changes. Forests are pervasive in the southern region, especially in the elevated areas and areas of higher rainfall. Slow growth hardwood forests

TABLE 12-14: CONVERSION OF LAND TO URBAN, TRANSPORATION, AND WATER USES, 1967-1977

State/Region	Acres Converted 1967-1977
Region 4	
Alabama	890,000
Florida	3,470,000
Georgia	1,400,000
Kentucky	760,000
Mississippi	720,000
North Carolina	1,280,000
South Carolina	920,000
Tennessee	770,000
Total	10,210,000
Region 6	
Arkansas	370,000
Louisiana	250,000
New Mexico	290,000
Oklahoma	250,000
Texas	2,260,000
Total	3,420,000
Sunbelt	13,630,000
U.S.	30,840,000

Source: Hidlebaugh, 1980.

of oak and hickory have been replaced typically with faster growth softwoods such as loblolly pine. Hardwood stands are also lost to urban and agricultural development. Bottomland hardwoods of the Mississippi River region, for example, are experiencing significant reduction in area extent (U.S., DOI, FWS, 1981) (see Figure 12-5). Although these forests are usually replaced with higher yield agricultural or forest products, they represent losses in quality hard woods and a reduction in environmental diversity.

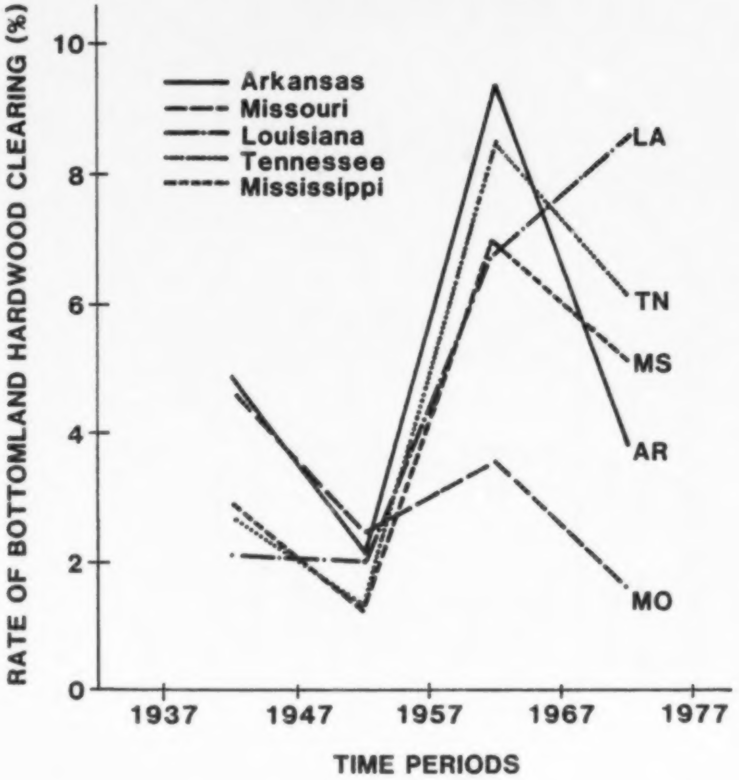

Figure 12-5: Bottomland Hardwood Forest Clearing Rate Comparison

Source: U.S., DOI, FWS, 1979b, p. 32.

12.3.4 Mining Reclamation

Adequate reclamation of mined lands has been an issue during the 1970's for many states, including several in the southern region. A variety of mining activities occurs in the southern states, including coal and sand and gravel mines (Table 12-15), and other mining activities such as phosphate, uranium, lead, lime-stone, and peat (U.S., DOI, FWS, 1980a). As evaluated by the Soil Conservation Service in 1977, about 700 thousand acres are in need of reclamation but are not covered by state or federal reclamation law. Two hundred and fifty thousand acres of coal mines now have reclamation standards covered by the federal Surface Mining Control and Reclamation Act (SMCRA) of 1977. According to the Soil Conservation Service, about 547 thousand acres of mined lands are not in need of additional reclamation.

TABLE 12-15: SOIL CONSERVATION SERVICE ASSESSMENT OF LAND DISTURBED BY SURFACE MINING AS OF JULY 1, 1977[a]
(acres; dashes indicate none)

State	Land Needing Reclamation						Land Not Requiring[b] Reclamation	Total Land Disturbed
	Reclamation Not Required by Any Law			Reclamation Required by Law (1977)				
	Sand and Gravel	Other Mined Areas	Coal Mines (federal)[c]	Coal Mines (state)[d]	Sand and Gravel	Other Mined Areas		
Alabama	16,611	19,929	72,292	34,807	5,498	5,498	85,673	241,062
Arkansas	21,483	11,479	5,623	2,859	20	1,592	9,449	52,505
Florida	11,162	235,700	---	---	3,365	20,922	61,266	332,415
Georgia	3,353	24,008	1,680	764	4,623	13,772	23,247	71,447
Kentucky	980	4,712	101,637	154,218	2,299	2,780	154,495	421,121
Louisiana[e]	37,324	2,549	---	---	---	---	10,467	50,340
Mississippi	45,966	7,821	---	---	---	---	14,415	68,202
New Mexico	11,860	1,806	22	3,709	1,057	26,072	2,207	46,733
North Carolina	11,908	4,792	---	---	7,096	3,909	7,000	34,705
Oklahoma	6,659	14,105	36,118	6,298	2,766	4,110	16,255	86,311
South Carolina	9,065	2,128	---	---	4,395	3,194	9,815	28,597
Tennessee	4,950	2,305	29,583	3,127	810	1,135	104,596	146,506
Texas	152,457	37,104	3,310	3,725	6,289	4,989	48,456	256,330
13-State Total	337,778	368,438	250,265	209,507	38,218	88,727	547,341	1,836,274

Source: U.S., DOI, FWS, 1980a.

[a] Based on information from Soil Conservation Service state offices.

[b] As judged by the Soil Conservation Service in 1977.

[c] These coal mine areas now must meet federal reclamation standards.

[d] These coal mines required reclamation under pre-1977 state and federal law.

[e] No state law when survey completed.

The mining issues in the Appalachian and Central Plains regions of the southern states are related primarily to potential coal strip mining areas, as shown in Figure 12-6. However, other mining problems also occur in these states, including the wetland-related problems associated with phosphate mining in central Florida, and uranium mine and tailings disposal problems in New Mexico and Texas. Because uranium, coal, phosphate, and other mining activities are expected to intensify, the following issues may become more significant during the coming decades:

- Conflict over state implementation of coal surface mine reclamation requirements. Southeastern states have not received approval by the DOI for their mine reclamation programs;
- Economic costs of requirements for restoration of original topography have been an issue raised by the mining industry. This problem is especially significant for surface mines in the Appalachian region;
- Uncertainties of impact of mines to soils, ground water, and surface water, especially in new mine areas such as the lignite fields of the Gulf Coast states. Water pollution and modification to local hydrology are continuing problems from phosphate mines in Florida; and
- Reclamation in the arid areas in New Mexico poses potential problems, especially in drought years. Revegetation provisions of SMCRA generally require that irrigation, mulching, and intensive management accompany mining in New Mexico.

In the Gulf Coast states, floodplain and wetlands restrictions represent a constraint on the location of lignite mines, for example, as much as 10 percent of the strippable lignite resource in Texas may be affected by prohibitions on mining in wetlands (Radian, 1979). Although, under special conditions and at increased costs, mining probably can be conducted in the floodplain, it is possible that under federal or state law, some of these areas may be declared unsuitable for mining (Radian, 1979). The floodplain and wetland constraints are greatest in the more humid eastern portion of Texas, and extend into Arkansas and Louisiana.

According to one study, increased surface mining is expected to result in the cumulative disturbance of approximately 374,000 acres of lignite area in Texas by the year 2000 (Radian, 1979).

Since the land will be reclaimed and revegetated, the amount of disturbed surface at any one time will be a small portion of the cumulative total. The total acreage which may be mined is small--less than one percent of the total habitat available.

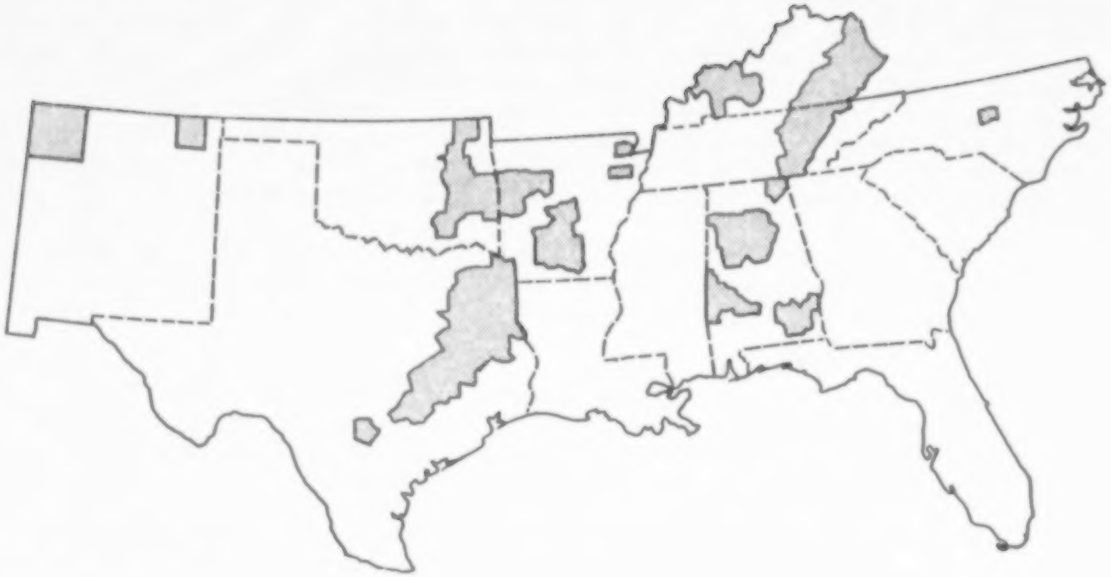

Figure 12-6: Potential Coal Strip Mining Areas

Source: Copenhaver, Olson, and Rice, 1978, p. 35.

However, wildlife populations are subject to considerable manmade disturbances. In addition, reclamation practices often rely on only one crop species, such as Coastal Bermuda and other grasses planted for grazing. This kind of vegetation provides little cover and food for wildlife (Radian, 1979).

Topographic modification, stream siltation, and acid mine drainage have been some of the impacts from surface and subsurface mining in Kentucky, Tennessee, and Alabama. In eastern Kentucky, for example, it is estimated that 175,000 acres of lands have been disturbed by surface mining through the early 1970's (Branscome, 1972). Reclamation of the disturbed soils is difficult due to their acidic nature (Grim and Hill, 1974). However, several erosion and sediment control procedures have been developed to minimize impact to streams (U.S., EPA, 1976). Increased coal mining predicted for the Sunbelt in the coming decades will create additional surface disturbances (see Chapter 6). Thus, mine reclamation will continue to be an important issue, particularly in areas experiencing lignite and bituminous coal development.

12.3.5 Wetlands Management Issues[1]

Coastal zone and wetlands areas currently are affected by a range of problems associated with population and industrial driving forces. Concerns include wetlands conversion, increased recreation needs, potential conflicts with fishing interests, needs for waste disposal sites, waterways dredging, land subsidence, and water pollution. In addition, salt water intrusion, management of barrier islands, and flooding and hurricane protection needs characterize some Atlantic and Gulf coast areas. These concerns are described in this section.

A. Conversion of Wetlands versus Preservation

Rapid urban growth of the coastal area has resulted in increased conversion of wetlands as coastal areas accommodate new businesses and residences. For example, in Louisiana, it has been predicted that if the present draining and filling operations for urban and commercial development in the coastal area continue, an additional 186,000 acres of the state's wetlands will be lost by the year 2000. An acre of marsh often produces more food (dollar value) than an acre of prime agricultural land. For example, in 1978 the value of an acre of wetland in Barataria Basin was about $9,100 (Mumphrey *et al.*, 1978).[2] Additional benefits of marsh lands include the protection they provide from the severity of storms and their ability to be used for waste treatment, up to a point, without an appreciable reduction in water quality.

Table 12-16 indicates the cumulative change from natural and man-made processes on one of the most extensive wetlands and coastal regions of the study area, the western portion of the Mississippi River Delta in Louisiana and Texas. Areas reclaimed as urban have increased 23.3 percent, but natural marshes have diminished 20 percent over a 22 year period ending in 1974 (U.S., DOI, FWS, 1979b). Agriculture, urbanization, and impoundments have significantly diminished marsh, forest, and beach habitat, and have expanded open waters and dredge spoil deposits.

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[1] Portions of this section are adapted from descriptions in the Coastal Zone Management Plan for Louisiana (U.S., Dept. of Commerce, NOAA, and La., Dept. of Natural Resources, 1980) and other state coastal zone management plans.

[2] Using this estimate for the value of an acre of wetland, the projected loss of 186,000 acres would add up to a $1.7 billion loss. The activities taken into consideration in deriving these estimate were commercial fishing, noncommercial fishing, commercial trapping, and recreation.

TABLE 12-16: ENVIRONMENT CHANGE 1952-1974 FOR THE MISSISSIPPI DELTA[a]
(hectares)

Environment Type	Net Area	Net Percentage Habitat Change
Nearshore Gulf	+ 1,539	+ 0.4
Open Water	+28,027	+16.2
Natural Marsh	-81,275	-20.3
Impounded Marsh	+38,111	+30.8
Natural Ridge	- 1,246	- 3.8
Spoil	+ 5,365	+23.1
Rice	+ 2,787	+ 6.7
Non-Rice Agriculture	+ 1,826	+29.0
Pasture	+ 1,181	+ 1.3
Socio/Economic (Urban Areas)	+ 5,446	+23.3
Beach	- 116	- 1.8
Upland Forest	- 1,246	- 7.2
Swamp Forest	- 396	- 5.7

Source: U.S., DOI, FWS, 1979b.

[a] The Chenier Plain area.

Both private and public agencies have been successful in many instances in protecting valued wetlands as game preserves, parks, and for natural values. EPA and the Corps of Engineers have broad review powers in preserving wetlands from encroachment by industrial development or as transportation corridors. In St. Charles Parish, Louisiana, for example, EPA, in cooperation with the State Highway Department and the U.S. Fish and Wildlife Service, preserved about 1,000 acres of wetlands that would have been destroyed by a highway (U.S., EPA, Office of Planning and Management, 1980). Common agreement was reached on siting the highway on higher ground and using construction practices that minimized wetlands intrusion.

Coastal wetlands are a sportsmen's paradise, offering scenic opportunities for fishing, hunting, boating and other water-related recreational activities. The management of recreational areas will become a greater concern as the urban centers grow and the utilization of recreational areas increases.

B. Commercial and Sport Fishing Issues

Commercial fishing is an important industry contributing to the economy of most coastal states. The region harvests about 49 percent of the U.S. fish catch (Table 12-17). Presently, the fishing industry faces a number of serious problems because it relies on continued maintenance of the estuarine fishery habitat. Problems facing the fishing industry in the Gulf Coast include underwater obstructions and the lack of support facilities. Underwater obstructions cause costly damage to fishing gear and boats and threaten navigation safety along coastal waters. Fishing interest groups are aware that wetlands and other habitats have been reduced by dredge and fill projects, saltwater intrusion, impoundments, leveeing, and channel dredging (LACCMR, 1973, p. 7). Land loss has already resulted in an economic loss in fishery products estimated at between \$8 and \$17 million dollars annually in Louisiana (Craig and Day, 1977; Conner et al., 1976; and CEI, 1976). The leveeing of the Mississippi River, although providing valuable flood protection, has adversely affected coastal wetlands by blocking the flow of freshwater and nutrients. This has increased saltwater intrusion and already affected important fisheries including reduced white shrimp stocks (U.S., Dept. of Commerce, NOAA, 1980).

C. Local Waste Discharge and Disposal Sites

Sources of coastal water pollution, like other areas, occur in two major categories: point sources which include discharges from municipal sewage treatment and industrial waste treatment plants; and nonpoint sources including runoff from such activities as housing, industrial development, and agriculture (see Chapter 14). Historically, the net adverse impact on coastal waters and wetlands as a result of these two sources is a reduction in the general water quality of the coastal region. However, there have been several recent improvements in coastal water quality, as indicated in Table 12-18.

The elimination of chemical waste disposal in the Gulf of Mexico is a major development in reducing direct additions to pollutants in the coastal area. In 1972, the dumping of 1.4 million tons of chemical wastes was authorized under permitting provisions of the Marine Protection, Research, and Sanctuaries Act of 1972 (U.S., EPA, Office of Planning and Management, 1980). EPA made permits conditional on the development of alternative disposal plans, with priority on eliminating toxic substances such as chlorinated hydrocarbons. By 1974, the volume of wastes dumped into the Gulf was 950,000 tons, and by 1975 it was down to 140,000 tons. By 1980, all dumping into the Gulf was eliminated (U.S., EPA, Office of Planning and Management, 1980).

TABLE 12-17: COMMERCIAL AND MARINE RECREATIONAL FISHERIES CATCH BY STATE (thousand pounds)

State	1976 Commercial Landings[a]	1974 Marine Recreational Catch	
		Finfish[b]	Shellfish[c]
Alabama[d]	34,953	10,756	1,039
Arkansas[e]	10,300		
Florida	164,955	164,235	58,604
Georgia	14,524	9,601	1,165
Kentucky[e]	2,945		
Louisiana	1,227,958	61,541	17,409
Mississippi	291,904	9,883	1,447
North Carolina	226,065	26,753	7,641
Oklahoma[e]	575		
South Carolina	21,481	17,793	6,441
Tennessee[e]	6,800		
Texas	96,305	51,936	9,725
Total	2,098,765	289,438	103,471
U.S.	5,350,400		
Percent of U.S.	39		

Source: U.S., Dept. of Commerce, NOAA, 1978.

[a] Statistics are for live weight of finfish and weight of meat (excluding shell) of shellfish.

[b] Statistics are for live weight.

[c] Statistics are for live weight including shells.

[d] Landings of interior waters estimated.

[e] Estimated.

TABLE 12-18: EXAMPLES OF COASTAL WATER IMPROVEMENT

Location	Period of Maximum Degradation	Causes	Effects	Improvements
Charleston Harbor, South Carolina	1940-1970	Raw sewage, river diversion, industrial discharge	Crab mortality, fish kills, surface scum	Since 1970: primary sewage treatment (fishing still impeded, scum removed, shrimp returning)
Escambia Bay, Florida	1950-1970	Thermal discharges, chemical industry discharges, pulp and paper mill wastes, drainage restrictions	Numerous fish kills, loss of oyster and shrimp fishery	Since 1970-72: reduction of industrial discharges, restoration of bay circulation (fishery improvements)
Perdido Bay, Alabama and Florida	1940-1970	Pulp and paper mill discharges	Discoloration, swimming impossible, loss of shell fish	Treatment of pulp mill effluent (restoration of swimming and fishing)

Source: Data from U.S., EPA, Office of Planning and Management, 1980, pp. 53-56.

Despite these improvements, some coastal wetlands are still used as waste disposal sites for solid or stored liquid wastes. Leachates from both types of wastes can adversely affect water quality. Storage of hazardous or nuclear wastes in the coastal zone creates a potential for serious pollution incidents if the integrity of such storage is breached by natural corrosion, weathering, or natural hazards.

Solid wastes from chemical and petrochemical industries have been disposed of in improperly constructed or poorly located landfill sites in some locations peripheral to the Mississippi River and its tributaries (Richards, 1979). Some of the disposal sites are along the lower Mississippi, the Mississippi Delta, and the surrounding wetlands. The contents of at least several sites leach directly into nearby aquatic systems and ultimately into the northern Gulf of Mexico (Richards, 1979). Of the contaminating organic compounds thus far identified, some are known to be toxic to man and to marine organisms. Procedures being implemented under the Resource Conservation and Recovery Act are intended to reduce these problems (see chapters 7 and 15).

Pollution from trace metals enter the Gulf of Mexico from a variety of sources, but rivers probably account for 90 percent of most metals entering the Gulf (Richards, 1979). The Mississippi is estimated to carry more than two-thirds of the river-borne trace metals entering the Gulf. An improved understanding of the behavior of trace metals in the Mississippi Delta and Gulf is critical to an assessment of any potential trace metal impact on organisms (Richards, 1979).

D. Problems with Dredging and Port Development

The shallow coastal zone of the Atlantic and Gulf coasts is crossed by man-made canals. Both oil and gas development and the growth of ports have played a major role in creation of new waterways in the Gulf Coast. These canals change the hydrology of the natural marsh system and create spoil disposal problems. In Louisiana, it is estimated that 25 percent of the 16.5 square mile average annual net land loss during the past 30 years is the direct result of petroleum industry dredging (Gagliano et al., 1973; Gagliano and Van Beek, 1970). In addition, the construction of channels, such as the Mississippi River Gulf Outlet, has increased saltwater intrusion, and thousands of acres of marshland have already been destroyed as a result of the construction of this channel. Smaller canals, such as those dredged for oil and gas activity, also create hydrological alterations. Canals are often dredged to install pipelines and the necessity of dredging many new canals could be allayed through multiple use of pipeline corridors.

Few ports in their present condition are sufficiently deep to accommodate the new large vessels used for the world transport of raw materials such as coal, particularly when vessels are loaded (Madison, 1981). Insufficient harbor depth is a major problem at most ports and dredging operations are included in most port modernization plans. The estimated cost of dredging the four harbors of Hampton Roads, Baltimore, New Orleans, and Mobile to a depth of 55 feet (from current depths ranging from 40 to 45 feet) is $1.5 billion (Madison, 1981).

Disposal of dredge spoils is a major issue in many near-shore areas. Along the Gulf Coast of Florida, for example, dredge spoils from Tampa Bay are being discharged into areas that fishermen and recreationists claim is valuable habitat (Kohlman, 1980). Location of disposal sites is a more critical issue as industrialization develops and environmental restrictions are imposed.

E. Subsidence Costs to Urban Areas

Wetland soils are susceptible to subsidence or sinking when drained. Subsidence in some areas is estimated to be as much as three or four feet. Although draining wetland areas costs society as a whole in terms of the loss in benefits the wetlands provide, direct costs are borne by the individual landowners. In Louisiana, the subsidence problem is common in Orleans, Jefferson, and St. Bernard parishes (Earle, 1975). It is estimated that the cost of developing a subdivision (exclusive of homes) in recently reclaimed wetlands is 50 percent greater than in areas of firmer soil (Mumphrey et al., 1976). Continued drainage and ground water use are likely to make subsidence problems a continuing concern.

F. Saltwater Intrusion

The problem of saltwater intrusion is increasing along some areas of the Gulf Coast. Oyster beds in Barataria Bay, Louisiana, are an example. Saltwater is steadily advancing up the bay and forcing the retreat of prime oyster bed areas into the upper reaches of the bay (Van Sickle et al., 1976; LACCMR, 1973, p. 33). Saltwater intrusion has also been observed in the freshwater areas which humans use as a source of drinking water (LACCMR, 1973, p. 142). Mean salinities in Lake Pontchartrain have increased from yearly averages of 1.3 parts per thousand in the early 60's to 4 to 9 parts per thousand in the early 70's (LACCMR, 1973, p. 143).

There are two primary reasons for increasing saltwater intrusion: the levee system along rivers and the dredging of new canals and waterways. Levees deprive the estuaries of the flow of freshwater, raising the salinity of the water in many places. During high river stages and rainy seasons, the canals move freshwater almost to the sea, changing brackish areas to freshwater; during low river stages, the canals allow the rapid inland advance of sea water.

G. Barrier Island Losses

The 300 barrier islands and spits along the Atlantic and Gulf coasts are valuable wildlife habitat and scenic recreation areas, and protect against marine erosion processes and hurricanes (U.S., CEQ, 1980). The tidal passes associated with barrier islands can be viewed in part as control valves of the estuaries because they regulate the amount of salinity intrusion and storm energy that enters the estuaries (Gagliano et al., 1973).

The barrier islands along the Gulf coast are being eroded. In Louisiana, the barrier islands of Grand Isle and Grand Terre were listed as areas of "critical erosion" by the U.S. Army Corps of Engineers (1971). Between 1960 and 1972, 172 acres (18 percent) of the principal Grand Terre island were eroded away. Between 1932 and 1969 the average rate of barrier island erosion was 119 acres per year. The width of the tidal passes in the Barataria Bay area is increasing, as is the rate of increase of width (Van Sickle et al., 1976).

The coastal erosion of the Barrier islands in and adjacent to the Mississippi River Delta is due to insufficient sedimentation from the Mississippi River, regional subsidence, hurricane damage, and man-induced changes such as dredging of canals on the bayside of a number of islands (Gagliano et al., 1973), and traversing of barrier islands by pipelines. Although barrier island losses are likely to be a continuing concern, especially in the Gulf of Mexico, in many areas coastal zone management plans have implemented stabilization programs to minimize additional barrier island losses.

The coastal zone of the Atlantic and Gulf coasts has suffered great loss of life and property because of floods and hurricanes. In 1979, hurricanes Frederick and David resulted in 10 deaths and $2.6 billion in property destruction (U.S., CEQ, 1980). The rapid urbanization of the coastal zone is resulting in greater numbers of people living in high hazard areas, thereby increasing the need for protective measures and means of evacuation. Improved public awareness of natural hazards and careful management of coastal development may help to reduce damages from flooding and hurricanes in the future.

12.3.6 Habitat and Endangered Species

A wide range of wildlife occupies the diverse ecoregions of the South. As indicated in Section 12.2 some of these species occupy coastal habitats, others have habitat requirements occurring farther inland. Migratory species such as waterfowl, for example, may require several habitat or ecosystem types. The size of species populations provides an indicator of the well-being of an ecosystem. Some wildlife populations are protected by the Bald Eagle and Golden Eagle Protection Act. Other legislation protects migratory birds and threatened and endangered species (Table 12-2). Continued changes in land use in the southern region can affect these populations.

The Endangered Species Preservation Act of 1973 codified concern for industrial and agricultural growth that accelerates species extinction. It has focused much attention on those organisms whose population numbers are low and whose habitat availability or quality is in danger of being diminished. Unfortunately, most available information on the abundance of rare or endangered species is based on historical ranges of the species in question, and little is available in the way of recent, specific location data.

Table 12-19 indicates the number of presently identified species and their state distribution. As indicated in the table, states vary widely in the number of endangered species. This is in part due to activity of biologists, knowledge of the biology of an area, and natural diversity of species. For example, Tennessee has the most species, in part due to extensive studies on native fishes, snails and clams, but also because of the extent and diversity of freshwater aquatic habitats in the state. The essential or critical habitat of rare and endangered species is protected from significant alteration by federally authorized projects. The process of identifying species to be included on the list and determining what habitat is essential is an activity of the Office of Endangered Species in the Fish and Wildlife Service. The process is accompanied by interagency, state, and public review. Critical habitat for selected species is summarized in Table 12-20. This summary table for selected species can be interpreted to indicate that many locations in Tennessee and Florida contain critical habitat. Much of the coastal area of south Florida, for example, is critical habitat. Thus, economic development or urban sprawl can be controlled in this area.

The well publicized snail darter critical habitat in the Little Tennessee River at the Tellico Dam site is as an example of the conflicts that can occur. The critical habitat was

TABLE 12-19: NUMBERS OF SPECIES FEDERALLY DESIGNATED AS ENDANGERED, THREATENED, PROPOSED, OR IN-REVIEW, SEPTEMBER, 1978

State	Mammals	Birds	Reptiles	Amphibians	Fish	Snails	Clams	Crustaceans	Insects	Plants[a]	Total
Alabama	7	6	6	1	14	4	7	1	0	15	61
Arkansas	8	7	2	0	7	3	1	0	0	24	52
Florida	10	9	10	1	4	2	0	3	4	7	50
Georgia	8	6	3	1	7	2	0	1	1	19	48
Kentucky	8	5	0	0	3	2	6	3	0	16	43
Louisiana	6	8	5	0	2	0	1	0	0	5	27
Mississippi	6	7	6	0	4	1	0	0	0	6	30
North Carolina	7	6	1	2	9	3	0	0	2	32	62
Oklahoma	9	6	2	0	2	1	0	0	0	6	26
South Carolina	7	6	2	1	1	0	0	0	1	20	38
Tennessee	8	5	0	0	14	16	16	4	0	22	85
Texas	12	9	8	5	9	3	1	0	3	6	56

Source: Brookhaven National Laboratory Endangered Species Data Base.

[a] Plant lists from Federal Register for all states except Arkansas are incomplete.

TABLE 12-20: EXAMPLES OF CRITICAL HABITAT

State	Species	Critical Habitat Area
Alabama	Slackwater Darter	Various counties
	Alabama Cavefish	Lauderdale County
Arkansas	Leopard Darter	Southwestern counties
Florida	Florida Manatee	Coastal waters
	Florida Everglades Kite	East of Miami area
	Dusky Seaside Sparrow	Parts of southern Florida
	Cape Sable Seaside Sparrow	Everglades National Park
Georgia	American Crocodile	Coastal waters
New Mexico	Whooping Crane	Socorro County
	Ridge-Nosed Rattlesnake	Hidalgo County
North Carolina	Spotfin Chubb	Little Tennessee River
Oklahoma	Whooping Crane	Salt Plains National Wildlife Refuge
	Leopard Darter	Southeastern counties
Tennessee	Indiana Bat	Blowhole Cave, Blount County
	Snail Darter	Little Tennessee River
	Slender Chubb	Various rivers
	Spotfin Chubb	Various rivers
Texas	Whooping Crane	Arkansas Wildlife Refuge
	Houston Toad	Bastrop County; Burleson County

Source: 50 CFR 17.95.

protected until Congress specifically exempted the Tellico Dam[1] from the Act's provisions and provided an interagency review mechanism to incorporate a broader constituency in cases where conflicts and issues over the Act arise. As land use changes continue in the southern region, concerns over critical habitat are likely to continue.

Table 12-21 lists "Important Resource Problems" (IRP's) identified by the U.S. Fish and Wildlife Service. Each IRP indicates that a certain species or community of species in a specified geographic area is or will be under a significant stress during the coming decade. Higher rankings indicate IRP's with more highly valued species or habitats which are threatened. A total of 78 problems have been adopted nationwide for planning purposes (U.S., DOI, FWS, 1980b). Figure 12-7 shows the distribution of the problem areas. Inland, the panhandle areas of Texas and Oklahoma and much of Tennessee also have problems with habitat management, according to the U.S. Fish and Wildlife Service.

12.4 SUMMARY

Land use and management issues are likely to intensify because of anticipated population, industrial, agricultural, and recreational growth in the southern region. Five categories of impact are important to changes in the environment as listed in Table 12-22. These include erosion, loss of critical habitat, dredging, filling, and loss of open spaces. The causal factors affecting these impacts that are likely to become increasingly important during the next two or three decades are forestry, mining, wetlands, and coastal zone development from urbanization, industrialization, and recreational uses. Locations where environmental issues are likely to be most intense are the coastal zone areas of Florida and northern sections of the Gulf Coast, such as the northcentral Texas coast, the Louisiana coastline, and the Mobile Bay area. For inland states, these issues arise in the Appalachian region of Kentucky and Tennessee, where energy, forest, agriculture, and wildlife issues have occurred and where development of the region is continuing. However, each of the other states has complex surface management issues. Additional local examples include:

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[1] As a postscript, the snail darter has recently been found in a tributary below the Tellico Dam, and transplants of the fish have also been made (Omang, 1980). However, it is not certain whether this population is adequate to sustain the existence of the species.

TABLE 12-21: IMPORTANT RESOURCE PROBLEMS IN FEDERAL REGIONS 4 AND 6 IDENTIFIED FOR 1980-85

Problem and Location	National Rank
Region 4	
Endangered Species (Wetlands and Keys of South Florida)	2
Migratory Waterfowl and Other Migratory Birds (Lower Missippi River)	5
Migratory Waterfowl (Coastal Marshes, Louisiana)	7
Endangered Birds/Bald Eagles (Lower 48 States)	19
Endangered Species (Unprotected Barrier Islands, Coastal States)	24
Migratory Waterfowl (Coastal Marshes, North and South Carolina)	32
Endangered Species (Coastal Georgia, North and South Carolina)	38
Endangered Cool and Cold Water Fish (Cumberland Plateau)	44
Estuarine and Anadromous Fish (North Carolina, South Carolina, Florida, Georgia, Mississippi, and Alabama)	49
Endangered Species (Mid-Gulf Drainage States)	50
Endangered Species and Waterfowl (Bottomland Hardwoods, Florida, and Georgia)	55
Region 6	
Endangered Birds and Migratory Birds (Coastal Texas)	4
Endangered Birds/Bald Eagle (Lower 48 States)	19
Migratory Birds (Rio Grande Valley, Texas)	21
Endangered Species (Unprotected Barrier Islands, Coastal States)	24
Endangered Species (Western Coal Development)	25
Migratory Waterfowl (Rio Grande/Pecos Basins, New Mexico)	57
Migratory Waterfowl (Playa Lakes [coastal areas])	59
Endangered Fishes (Edwards Aquifer, Texas)	60

Source: U.S., DOI, FWS, 1980b.

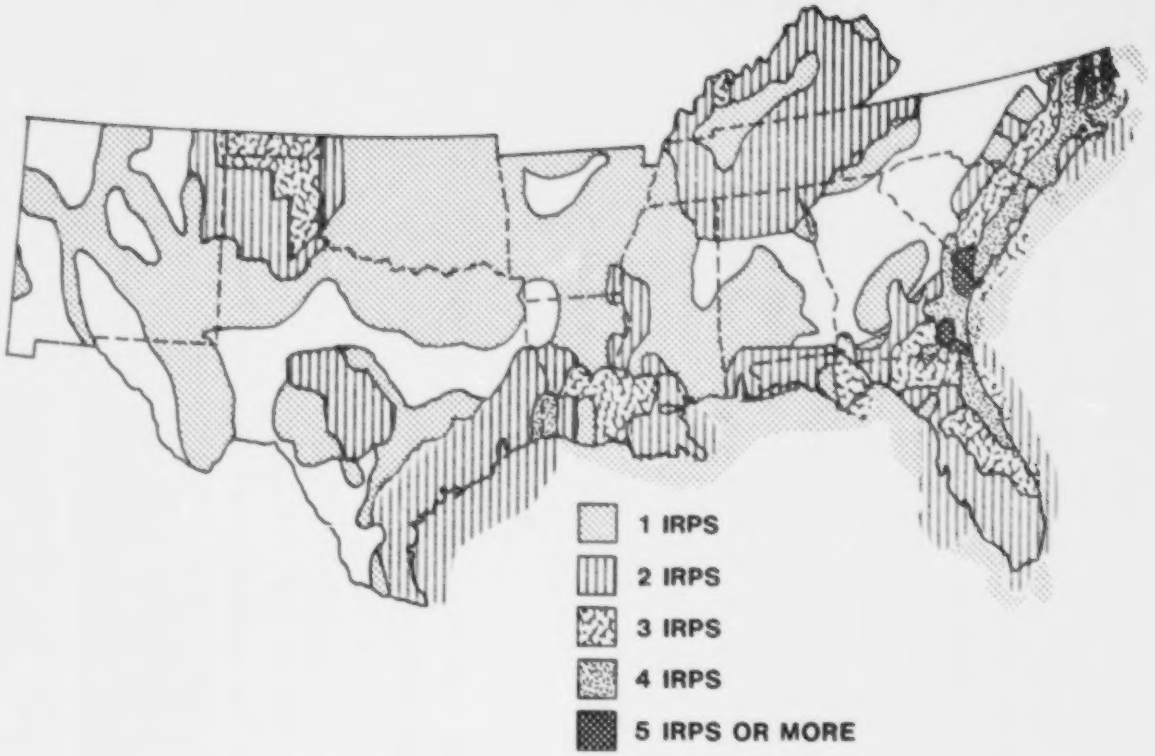

Figure 12-7: Distribution of Important Resource Problems

Source: U.S. DOI, FWS, 1980b, p. 16.

TABLE 12-22: ENVIRONMENTAL MATRIX: LAND AND COASTAL ZONE USE

Environmental Impact/Problem Areas	Causal Factors	Type of Problem Created	Duration	Area Affected	Policy Issues
Erosion	Poor management practices in crop production, forest harvesting, construction mining activities, strip mining	Ecological Aesthetic Economic	Permanent in severe instances Cumulative effects	Entire study area, but wind erosion confined to west	General: siting issues, improved agricultural management, forestry practices, increased mining
Loss of critical habitat	Population and industrial growth, expansion of cropland areas	Ecological	Permanent	Especially severe in coastal areas coastal	Siting, growth management
Dredging	Demand for clear and deep waterways for transportation, demand for ports, marinas, and housing	Ecological Aesthetic Health	Uncertain but long term effects of continuing practices	Coastal areas, inland waterways	Economic effects; ecological effects; alternative disposal sites
Filling wetland areas, wetland drainage	Urban sprawl and industrial demand for riverine and coastal sites, solid waste disposal, crop area expansion	Ecological Aesthetic	Permanent	Mississippi Valley, Gulf Coast	Alternative land use strategies
Loss of open space for habitat; recreational use	Urban sprawl, lack of funds or incentives for inventorying or setting aside lands, expansion of cropland areas	Ecological Aesthetic Economic	Some kinds are lost permanently, e.g., areas covered by urbanization and industrial expansion	All of study area except New Mexico	Options for recreation development

- North Carolina: control of urban and industrial development in the central region, peat mining;
- South Carolina: central industrialization, preservation of coastal habitat;
- Georgia: coastal management, urbanization, agricultural development, wetland preservation;
- Mississippi: waterways development;
- Arkansas: soil management and forestry;
- Oklahoma: forestry, irrigation projects; and
- New Mexico: mining development and changes in irrigated agriculture.

Many of the changes anticipated are relatively permanent, including transportation projects, drainage and filling activities, and continuing erosion. For some problems, such as water quality in the coastal zone, significant improvements have occurred, as in the bays on the Florida Panhandle and the elimination of toxic chemical dumping in the Gulf of Mexico. Other issues are likely to intensify, such as encroachment on prime agricultural lands and the reduction in some forest areas. Because of these continuing concerns, land use management is likely to be a continuing issue in the future decades for the southern region.

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CHAPTER 13

WATER AVAILABILITY

HIGHLIGHTS

- Status and Trends

1. The eastern two-thirds of the Sunbelt has historically had abundant water resources, while New Mexico, and parts of Texas and Oklahoma have a long history of surface water and ground water shortages. Water resources have been an important factor in the recent industrial growth of the Sunbelt.

2. Water consumption in Region 4 is projected to double by the year 2000. The largest increases are expected from steam electric generation (over 900 percent increase) and manufacturing (over 300 percent increase). Agricultural consumption is projected to increase 30 percent and will remain the largest water user, accounting for about 30 percent of total consumption in Region 4.

3. Water consumption by energy production is expected to increase significantly in all states of the study area except New Mexico. In Region 6, water consumption for steam electric generation is projected to increase over 500 percent by the year 2000.

4. Growth in four key manufacturing industries will place increasing stress on water resources: chemicals, primary metals, paper and allied products, and petroleum and coal products. Chemicals and primary metals are expected to grow over 300 percent in Region 6; petroleum and coal products is predicted to grow over 300 percent in Region 4.

- Geographic Areas

5. One of the most significant areas facing current water shortages is the Oklahoma and Texas panhandles, affected by depletion of the Ogallala Aquifer. This is causing shifts to dry land farming; it could adversely affect the economies of both states, and it is a multistate problem also affecting Kansas, Nebraska, and Colorado.

6. The South Atlantic Gulf area (North and South Carolina, Georgia, Florida, and Alabama) will face increasing stress on water resources. This will be due to growth of the paper and chemicals industries, agriculture, population, and increasing water quality problems.

7. Southcentral Texas could face serious water problems. This area faces rapid energy development, expansion of the chemicals industry, and rapid population increases. Ground water is already being overdrafted in many areas, salt water intrusion is a problem along the coast, surface water supplies are already tight, and water quality problems could increase.

- Key Problems and Issues

8. Ground water depletion is currently a problem in Texas, Oklahoma, Florida, and along the South Atlantic Coast. More areas will face ground water depletion, which can be a long-term problem requiring multistate cooperation and improved institutional mechanisms for managing this resource.

9. Surface water availability will become an increasingly significant concern throughout the Sunbelt, possibly restricting industrial and population growth. In the Southeast, this problem will present very difficult policy questions because of the historical abundance of water and riparian water law.

10. Completion of the Tennessee-Tombigbee Waterway will have both advantages and disadvantages to the Southeast. While controversy over this waterway seems unavoidable, the key need is to incorporate measures to mitigate environmental consequences in plans for completing the waterway.

11. States are in the central position to provide water resources for a variety of uses, but they will have fewer financial resources at their disposal. Thus, improved water management is needed in several states, including revisions or alternatives to riparian water laws, cooperative arrangements to manage ground water, means to improve management of multi-state river basins, and improved information systems.

CHAPTER 13

WATER AVAILABILITY

13.1 INTRODUCTION

Water availability has long been a problem in many parts of the Southwest which suffer from inadequate surface water and ground water supplies. Water availability has become more serious in the Southeast, especially where water quality degradation has limited some uses. As industrial and population growth continue in the Sunbelt, these concerns will increase. Key driving forces include expanded water needs for steam electric power generation, production of chemicals, pulp and paper, primary metals, and petroleum products, expanding agricultural uses, and a rapidly growing population. The use of water for recreational purposes is also important to the attractiveness of the South (see Chapter 2). In addition to increasing the competition for water, these and other driving forces can create water quality problems (see Chapter 14). Thus, policies to provide adequate water in the Sunbelt will need to account for the relationship between quantity and quality of the resource.

This chapter addresses water availability concerns throughout the Sunbelt. The following section (13.2) describes existing water resource conditions, including a brief overview of the regulatory system, surface and ground water resource characteristics, and the past trends in water use. Section 13.3 examines trends and issues in water availability. This includes a description of key driving forces and four problem areas--ground water depletion, region-wide water shortages, completion of the Tennessee-Tombigbee Waterway, and the need for improved water management.

13.2 EXISTING CONDITIONS

13.2.1 The Regulatory System

Control of water allocation has been predominantly a state function. Within states, administration of surface water has generally been based on either a riparian or an appropriation doctrine. The riparian doctrine, which has developed primarily in states that historically have had adequate flows, stipulates that an unlimited amount may be taken by any user owning property adjacent to the stream as long as the use does not adversely affect downstream users. Thus, during periods of adequate flow any reasonable rates of withdrawal can be supported.[1] During periods of low flow, priorities established by the state guide the amount available to any particular user.

The appropriation doctrine has developed in areas experiencing inadequate surface supplies. This system, often referred to as "first in time, first in right," establishes a clearer set of priorities for water use. A continuing right is granted to the first user of water.[2] A second user, whether upstream or downstream, is entitled to use his right only if enough remains after the senior user has met his needs. Thus, in the appropriation system, secondary or "junior" users often may be denied their full allocation.

Figure 13-1 identifies the surface water laws for the Sunbelt region. Only New Mexico is currently an appropriation state. Oklahoma, Texas, Mississippi, and Florida have mixed systems and the remaining eight states are riparian. For example, Mississippi and Florida have permit systems which employ most of the principles of the Appropriation Doctrine without establishing use priorities during critical periods.

Ground water law has developed independently of surface water law, usually because of the mistaken view that surface and ground waters were not hydrologically connected. Thus, historically ground water was viewed to be owned by the property owner. Most western states now require applications or permits for ground water use, but most eastern states regulate ground water only in areas of critical water shortage. States of the Sunbelt can be classified in four categories of ground water law. These laws can vary within a state, depending on whether the source is an underground stream, percolating water, or a spring:

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[1] Several terms are central to understanding water use. Withdrawal (sometimes referred to as diversion) is the amount of water physically removed from a stream. Consumption is the portion of the withdrawal required for crop growth, industrial use, domestic purposes, etc. For agricultural water use, the term return flow refers to that portion of water withdrawn for irrigation which returns to accessible surface or ground waters. While most water which is not consumed is returned to the stream, a small percentage is irrecoverably lost to evaporation, phreatophyte consumption, or to irretrievable ground waters.

[2] Rights are obtained by application to a state water engineer or water court. Rights are granted for specific uses and quantities.

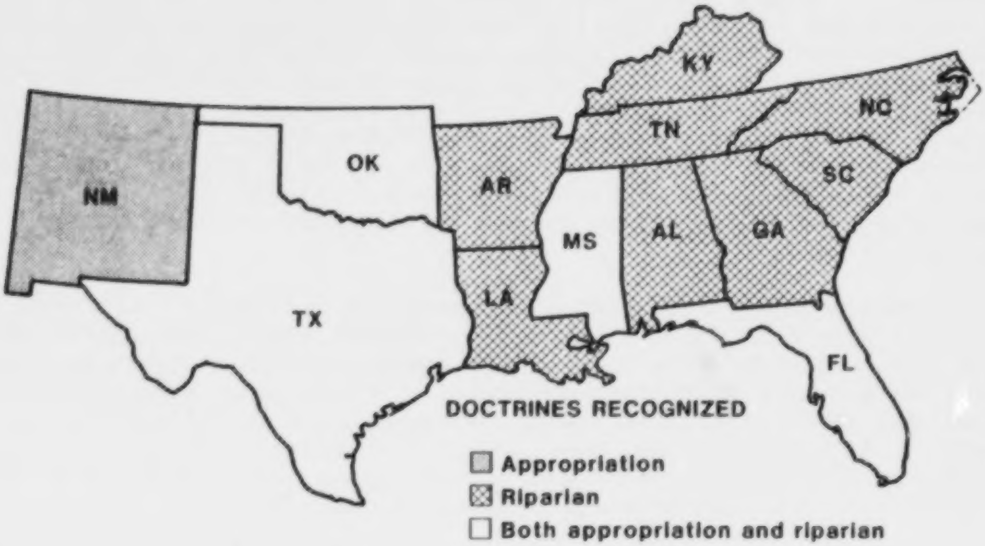

Figure 13-1: Surface Water Laws

Source: Geraghty *et al*., 1973, Plate 33.

1. Absolute ownership: a landowner can withdraw any water from beneath his land without liability to his neighbors.

2. Reasonable use: each landowner is restricted to a reasonable exercise of his rights, in view of similar rights held by his neighbors.

3. Correlative rights: among landowners overlying the same ground water resource, each landowner can make a reasonable use of that supply so long as the source is sufficient. When the source is insufficient, each landowner is entitled to water in proportion to the percent of his land to all other lands overlying the source.

4. Prior appropriation: ground water is subject to appropriation for beneficial use, providing the user complies with statutory requirements, permits, or licenses.

All of these ground water law systems are used in the Sunbelt. The most common is the Reasonable Use Doctrine, prevalent in Arkansas, Alabama, Georgia, North Carolina, and Tennessee. This is very close to the riparian doctrine for surface water; in fact, Tennessee does not legally distinguish surface and ground waters. Three states have absolute ownership--Texas, Louisiana, and Mississippi. Kentucky is the only state recognizing correlative rights, while Oklahoma, New Mexico, and Florida have prior appropriation systems. South Carolina has a mixed system; reasonable use is applicable for withdrawals under 100,000 gallons per day (gpd) while withdrawals in excess of 100,000 gpd are subject to appropriation.

Treaties and compacts have become increasingly important to the allocation of water resources. Table 13-1 shows water treaties and compacts affecting the Sunbelt region. The need for these agreements developed because of inadequate supplies in some river basins--all of the eleven agreements are for rivers in Region 6 and most affect New Mexico and Texas. These treaties are primarily intended to allocate water among the states in times of shortage and to preserve minimum stream flows.

Water availability is also influenced by water quality legislation. The Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977 have established national water quality goals and established the basic regulatory system for limiting pollution discharges and treating wastewaters. Water quality regulations can be important to water use and availability; for example, requirements limiting thermal pollution have contributed to the use of cooling towers which can result in increased water consumption. (Refer to Chapter 14.2 for an elaboration of water quality regulation).

13.2.2 Overview of Water Resources

A. Surface Water

The study area includes nine water resource regions representing major hydrologic basins (Figure 13-2). These regions are useful in making general characterizations of areas where water is physically limited or subject to large variations in flow.

As suggested previously, water is most physically limited in the Southwest (Region 6). The fundamental cause is the semiarid climate, resulting in low precipitation levels in New Mexico, Texas, and Oklahoma. For example, rainfall averages 10 to 20 inches per year in New Mexico and parts of Oklahoma and Texas, contrasted with 50 to 60 inches per year throughout most of Region 4 (see Figure 13-3). Thus, the water resource regions experiencing water shortages are the western and central portions of the Arkansas-White-Red, western and central portions of the Texas Gulf

TABLE 13-1: TREATIES AND COMPACTS AFFECTING WATER RESOURCES IN THE SUNBELT

Treaty/Compact	Signatories	Major Provisions
Rio Grande Convention (1906)	U.S. Mexico	The U.S. is entitled to use all water of the Rio Grande between Juarez and Ft. Quitman, Texas.
Rio Grande, Colorado and Tijuana Treaty (1944)	U.S. Mexico	Fifty percent of the unallocated flow of the Rio Grande is allocated to each country. Delivery from Mexico to U.S will be a minimum of 350 MAFY. The U.S. guarantees a minimum of 1.5 MMAFY of the Colorado River to Mexico. Minimum quality requirements (salinity) are established for this flow.
Arkansas River Basin Compact (1965)	Kansas Oklahoma	Allocates reservoir construction. Kansas is entitled to 100 percent of average natural flow plus a portion of the new reservoir storage.
Arkansas River Basin Compact (1970)	Oklahoma Arkansas	Oklahoma is entitled to a maximum of 60 percent of the flow of the Arkansas basin. Arkansas is entitled to a maximum of 50 percent from the Spavinaw Basin, 60 percent from the Illinois and Poteau Basins, and 100 percent from Lee Creek.
Canadian River Compact (1950)	New Mexico Oklahoma Texas	Allocates reservoir water. Establishes a commission to determine flow requirements.
Sabine River Compact (1953)	Louisiana Texas	Fifty percent of the river is allocated to each state.

(continued)

TABLE 13-1: (continued)

Treaty/Compact	Signatories	Major Provisions
Costilla Creek Compact (1963)	Colorado New Mexico	Colorado is allocated 36.5 percent of the flow and New Mexico 63.5 percent.
Rio Grande Compact (1938)	U.S. Texas New Mexico Colorado	Allocation to the three states is determined by an upstream flow index.
Pecos River Compact (1948)	New Mexico Texas	Establishes a minimum flow based on 1947 conditions. Also allocates 50 percent of the flood waters to each state; 43 percent of the salvaged water to Texas; and 57 percent of salvaged water to New Mexico.
Colorado River Compact (1922)	Arizona California Colorado Nevada New Mexico Utah Wyoming	Divides waters of Upper and Lower Basins of the Colorado. Guarantees 75 MMAF at Lees Ferry, Arizona, in any 10-year period.
Upper Colorado River Basin Compact (1948)	Arizona Colorado New Mexico Utah Wyoming	Allocates 50 MAFY to Arizona. The remainder is allocated as follows: New Mexico 11.25% Colorado 51.75% Utah 23.00% Wyoming 14.00%
LaPlata River Compact (1922)	Colorado New Mexico	Allocates 50 percent of the flow to each state if flow is less than 100 cfs. Otherwise, use is unrestricted.

MAFY = thousand acre-feet per year.
MMAFY = million acre-feet per year.
cfs = cubic feet per second.

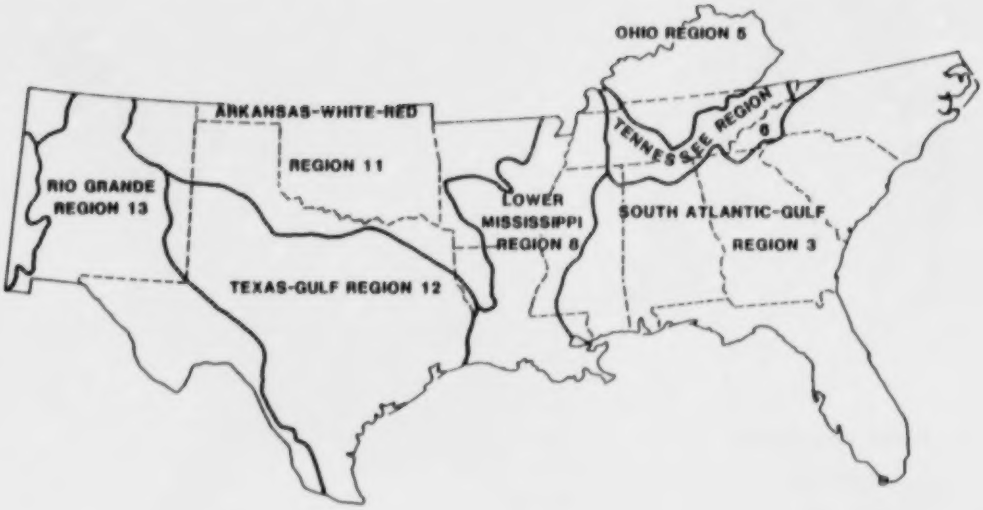

Figure 13-2: Water Resources Regions

Source: U.S., WRC, 1978a, p. 5.

region, the Rio Grande region, and the portions of the Upper and Lower Colorado regions in New Mexico. Severe water shortages are common in New Mexico, along the Rio Grande in Texas, and along the Oklahoma-Texas border. In addition, rainfall in New Mexico, Texas, and Oklahoma is subject to high variability; thus river flows generally are high in the spring but low in summer and fall.

In contrast, water is physically available and subject to relatively uniform annual flows throughout much of the Southeast. This is particularly true for the South Atlantic Gulf region and the Lower Mississippi region. The area drained through the Lower Mississippi region has an average stream discharge of approximately 430 billion gpd (480 MMAFY). This represents about 45 percent of the average stream discharge for the entire region (U.S., WRC, 1978a, p. 15).

Abundant water also characterizes the Tennessee and Ohio regions. However, high variability in flow is typical throughout Kentucky and in portions of Tennessee and North Carolina, causing

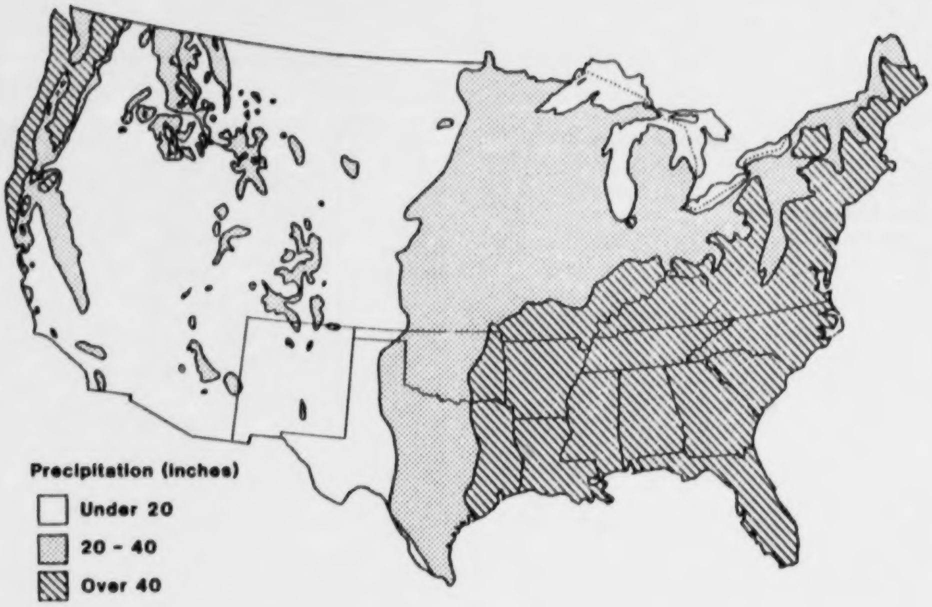

Figure 13-3: Annual Precipitation

localized shortages at times and extensive flood damage at others. The Tennessee Region has undergone significant development of its water resources by the Tennessee Valley Authority, which regulates streamflow through a system of 37 reservoirs. This regulation of water provides hydroelectric power and flood control and augments flows during the dry season.

B. Ground Water

Several major aquifers run through the study area, as illustrated by Figure 13-4. The coastal plain region, including the highly productive Floridian Aquifer, is estimated to contain the largest reserve of ground water in the nation (Geraghty et al., 1973). In the Appalachian Region, ground water supplies are generally adequate for most domestic purposes but are not considered adequate to support increased agricultural or industrial activity. Some areas in the eastern section do have ground water shortages, including northern Alabama, and portions of Mississippi and Louisiana.

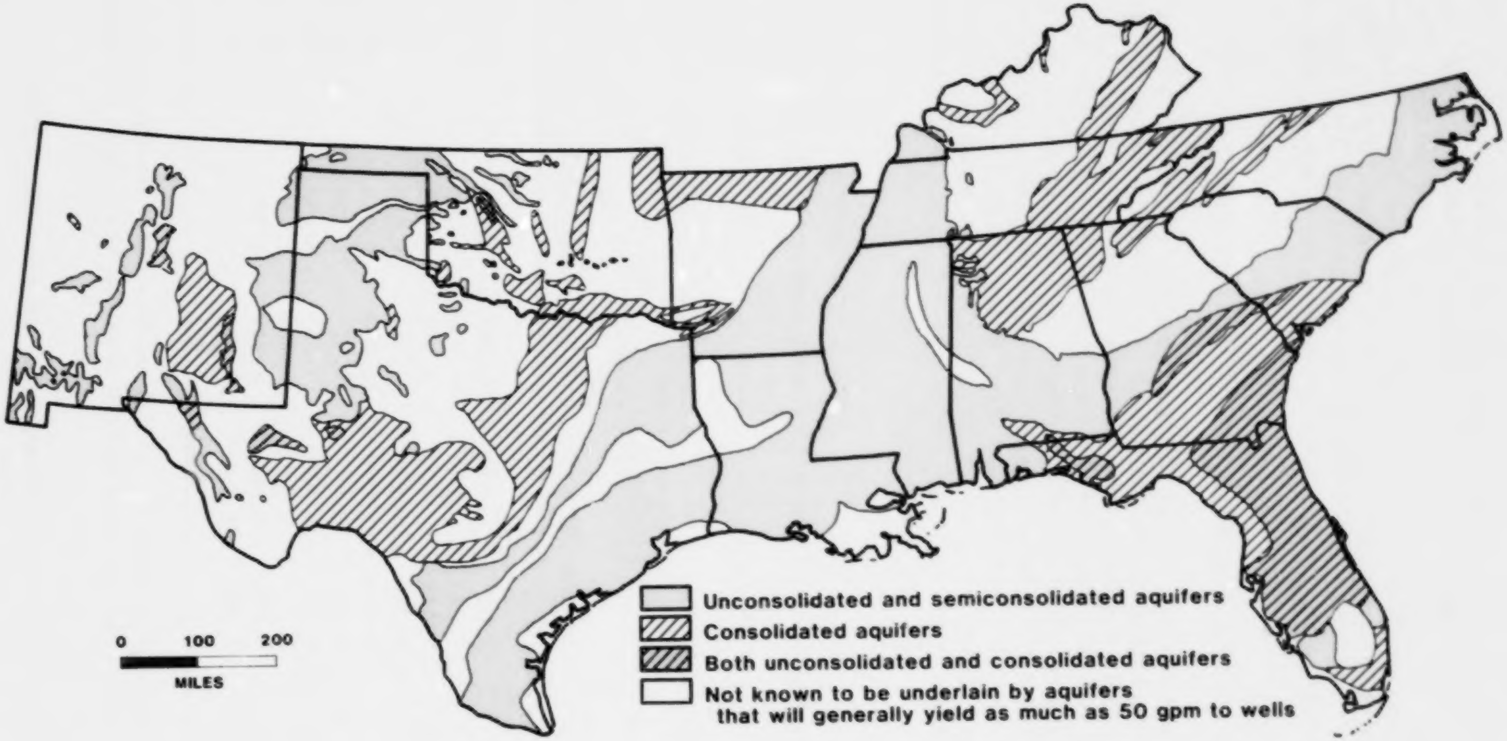
Unconsolidated and semiconsolidated aquifers
Consolidated aquifers
Both unconsolidated and consolidated aquifers
Not known to be underlain by aquifers that will generally yield as much as 50 gpm to wells
0
100
200
MILES

Figure 13-4: Ground Water Resources of the Sunbelt

Source: Thomas, 1951.

More severe ground water shortages exist in Region 6. The major aquifers in this region are the Ogallala in the High Plains and aquifers along the gulf coast of Texas and Louisiana. Severe overdrafts have been occurring for years in these aquifers--most notably throughout the Ogallala and in the Houston area. For example, over 50,000 irrigation wells pump water from the Ogallala in Texas alone, resulting in a rapidly decreasing water table.

13.2.3 Water Use in the Sunbelt

Estimates of water use by resource region for 1975 are shown in Table 13-2. Total water withdrawals, including surface water and ground water, are highest in the Ohio and South Atlantic-Gulf regions--representing 45 percent of the total withdrawals for these nine water resource regions. However, consumption is highest in the Texas Gulf and Arkansas-White-Red regions--representing 46 percent of the total consumption for these nine regions. Consumptive use ranges from 4 percent of total withdrawals (Tennessee region) to 67 percent (Rio Grande region). A high percentage of

TABLE 13-2: FRESH WATER USE IN WATER REGIONS OF THE SUNBELT, 1975
(millions of gpd)

Water Resource Region	1975 Fresh water Withdrawals			1975 Consumption	Percent Consumed[a]
	Surface	Ground	Total		
South Atlantic-Gulf	19,061	5,499	24,560	4,867	20
Ohio	33,091	1,843	34,934	1,798	5
Tennessee	7,141	271	7,412	313	4
Lower Mississippi	9,729	4,838	14,567	4,027	28
Arkansas-White-Red	4,022	8,846	12,868	8,064	63
Texas Gulf	9,703	7,222	16,925	11,259	66
Rio Grande	3,986	2,335	6,321	4,240	67
Upper Colorado	6,743	126	6,869	2,440	36
Lower Colorado	3,909	5,008	8,917	4,595	52
Total	97,385	35,988	133,373	41,603	31

Source: U.S., Water Resources Council, 1978a, p. 25. See Appendix A for an overview of the methodology and assumptions used in the Second National Water Assessment.

[a] Ratio of consumption (1975) to total fresh water withdrawals (1975).

consumptive use occurs in each of the major water regions of the Southwest--63 percent in the Arkansas-White-Red, 66 percent in the Texas Gulf, and 67 percent in the Rio Grande.

Tables 13-3 through 13-6 present data on water withdrawal and consumption by major use category for each of the 13 states. While total water withdrawals are about the same for the two regions in our study area, water consumption is more than four times higher in Region 6 than in Region 4. In Region 6, 57 percent of the water withdrawn is consumed, while in Region 4, only 14 percent of the water withdrawn is consumed. These differences reflect the significance of irrigated agriculture throughout Region 6--agriculture consumes about six times as much water in Region 6 as it does in Region 4.

Within Region 6, agriculture is the major water consumer in each state, representing from 60 percent to 92 percent of state consumption (see tables 13-3 and 13-4). In Arkansas, New Mexico, and Texas, agriculture accounts for 90 percent or more of the water consumption. Of these states, Texas is by far the largest water consumer, accounting for 68 percent of total water consumption in the region. As of 1975, industrial uses of water represented a

TABLE 13-3: WATER WITHDRAWALS IN REGION 6, 1975[a]
(millions of gpd)

State	Agriculture	Steam Electric	Manufacturing	Domestic	Other	State Total
Arkansas	2,292	427	351	165	141	3,376
	(68%)	(13)	(10)	(5)	(4)	(100)
Louisiana	1,963	2,868	3,531	420	778	9,561
	(21%)	(30)	(37)	(4)	(8)	(100)
New Mexico	3,673	64	13	161	290	4,200
	(87%)	(2)	(1)	(4)	(7)	(101)
Oklahoma	1,176	230	158	232	251	2,048
	(57%)	(11)	(8)	(11)	(12)	(99)
Texas	17,525	758	2,072	1,211	1,413	22,979
	(76%)	(3)	(9)	(5)	(6)	(99)
Total	26,629	4,347	6,125	2,189	2,873	42,161
	(63%)	(10)	(15)	(5)	(7)	(100)

Source: Sheppard et al., 1980, Appendix C, Table C.2.

[a] Some row percentages may not add to 100 due to rounding.

TABLE 13-4: WATER CONSUMPTION IN REGION 6, 1975[a]
(millions of gpd)

State	Agriculture	Steam Electric	Manufacturing	Domestic	Other	State Total
Arkansas	1,566	14	46	48	31	1,704
	(92%)	(1)	(3)	(3)	(2)	(101)
Louisiana	1,296	39	254	227	342	2,158
	(60%)	(2)	(12)	(11)	(16)	(101)
New Mexico	2,432	26	16	73	98	2,646
	(92%)	(1)	(1)	(3)	(4)	(101)
Oklahoma	972	40	43	95	95	1,246
	(78%)	(3)	(3)	(8)	(8)	(100)
Texas[b]	14,228	180	565	1,040	571	16,584
	(86%)	(1)	(3)	(6)	(3)	(99)
Total	20,494	299	923	1,483	1,137	24,338
	(84%)	(1)	(4)	(6)	(5)	(100)

Source: Shepherd et al., 1980, Appendix C, Table C.2.

[a] Some row percentages may not add to 100 due to rounding.

[b] Water consumption in Texas for steam electric, manufacturing, and domestic uses have been updated by recent data from the State of Texas--therefore these data do not correspond to those found in Shepherd et al (1980). Source of updated data is personal communication, Texas Department of Water Resources, September 23, 1981.

very small percentage of water use in each state, with the exception of Louisiana which had 12 percent of its consumption accounted for by manufacturing. Steam electric generation accounted for only 1 percent of Region 6 water use in 1975.

In Region 4, Florida accounts for 56 percent of the region's water consumption, again reflecting the importance of irrigated agriculture to that state's economy. Only in Florida and Mississippi does agricultural water use account for a majority of the water consumption. Next to agriculture, the second largest water use in Region 4 is domestic, accounting for 17 percent. In two states (North Carolina and South Carolina), the primary use is domestic. This largely reflects the fact that these states have very small consumptive water requirements. Manufacturing accounts for 14 percent of the consumption in Region 4 and is the primary consumptive user in Alabama, Kentucky, and Tennessee.

Steam electric, which includes coal, gas, and nuclear generation facilities, represents the largest category of water withdrawal in Region 4, accounting for 58 percent. However, consumption of water by steam electric is quite low, representing only 5 percent of consumptive use in Region 4. Large withdrawals with small consumption for steam electric use were attributed to the prevailing use of once-through cooling processes. In the past, over 99 percent of the withdrawals have been returned to the receiving stream at an elevated temperature. This practice no longer continues because of the Federal Water Pollution Control Act of 1972, which restricts thermal discharges. This restriction, which is important to water quality, will lead to increased water consumption for steam electric generation (see tables 13-5 and 13-6).

TABLE 13-5: WATER WITHDRAWALS IN REGION 4, 1975[a]
(millions of gpd)

State	Agriculture	Steam Electric	Manufacturing	Domestic	Other	State Total
Alabama	44	4,472	1,427	310	180	6,433
	(<1%)	(70)	(22)	(5)	(3)	(101)
Florida	3,193	1,979	708	1,049	375	7,304
	(44%)	(27)	(10)	(14)	(5)	(100)
Georgia	194	2,475	905	484	277	4,336
	(4%)	(57)	(21)	(11)	(6)	(99)
Kentucky	53	2,606	546	161	209	3,575
	(1%)	(73)	(15)	(5)	(6)	(100)
Mississippi	383	265	497	187	98	1,431
	(27%)	(19)	(35)	(13)	(7)	(101)
North	111	2,892	734	546	158	4,442
Carolina	(2%)	(65)	(17)	(12)	(4)	(100)
South	36	2,558	457	342	130	3,522
Carolina	(1%)	(73)	(13)	(10)	(4)	(101)
Tennessee	48	4,865	1,886	326	176	7,301
	(1%)	(67)	(26)	(4)	(2)	(100)
Total	4,062	22,112	7,165	3,405	1,703	38,344
	(11%)	(58)	(19)	(9)	(4)	(101)

Source: Shepherd _et al_., 1980, Appendix C, Table C.2.

[a] Some row percentages may not add to 100 due to rounding.

TABLE 13-6: WATER CONSUMPTION IN REGION 4, 1975[a]
(millions of gpd)

State	Agriculture	Steam Electric	Manufacturing	Domestic	Other	State Total
Alabama	41	33	186	52	29	341
	(12%)	(10)	(55)	(15)	(9)	(100)
Florida	2,557	17	123	302	103	3,102
	(73%)	(1)	(4)	(10)	(3)	(101)
Georgia	155	41	72	137	44	449
	(35%)	(9)	(16)	(31)	(10)	(101)
Kentucky	48	54	88	45	61	296
	(16%)	(18)	(30)	(15)	(21)	(100)
Mississippi	284	8	55	78	27	452
	(63%)	(2)	(12)	(17)	(6)	(100)
North Carolina	89	39	52	164	25	370
	(24%)	(11)	(14)	(44)	(7)	(100)
South Carolina	30	35	45	73	18	201
	(15%)	(17)	(22)	(36)	(9)	(99)
Tennessee	45	33	131	58	28	295
	(15%)	(11)	(44)	(20)	(9)	(99)
Total	3,249	260	752	909	335	5,506
	(59%)	(5)	(14)	(17)	(6)	(101)

Source: Shepherd et al., 1980, Appendix C, Table C.2.

[a] Some row percentages may not add to 100 due to rounding.

13.3 FUTURE TRENDS AND ISSUES

13.3.1 Key Driving Forces

Water use patterns in the Sunbelt will change in response to increased population, industrial and energy growth, water pollution regulations, and changing land use patterns. Projections for water consumption for Region 6 and Region 4 from the Second National Water Assessment are shown in Figure 13-5 (U.S., WRC, 1978b).[1]

In Region 6, consumption is projected to remain at about 23 billion gpd through the year 2000.[2] This projection largely reflects the inadequacy of surface and ground water supplies to support increased demands--for example, rapid depletion of the Ogallala Aquifer has already forced some shift from irrigated to dry land farming. Water consumption in agriculture is projected to decrease by 17 percent by the year 2000, as shown in Table 13-7. This decrease represents about 3.5 billion gpd. Offsetting this decline is an expected 3.4 billion gpd increase in steam electric and manufacturing uses. Over 70 percent of the increase in steam electric uses are projected for Texas, while most of the manufacturing increase is projected for Texas (65 percent) and Louisiana (26 percent).

Water consumption by domestic and other users is projected to remain stable during the next 20 years despite rapid population increases in much of the region. For example, domestic uses are projected to decrease 21 percent by the year 2000, and will only represent about 5 percent of total regional consumption by that year. These projections assume improvements in delivery systems and increased efficiency of use. If these improvements do not occur, the stress on water supplies in Region 6 will increase.

In contrast to Region 6, Region 4 is projected to experience a doubling of fresh water consumption by the year 2000--from 5.5 billion gpd to about 12 billion gpd. Most of this increase can be attributed to manufacturing and steam electric demands. As shown in Table 13-8, steam electric uses are projected to increase by over 900 percent by 2000, with large increases expected in every state except Florida and Mississippi. Manufacturing uses are expected to increase by over 300 percent, largely in Florida, Alabama, Tennessee, and Georgia. In 1975, steam electric uses were estimated to account for about 18 percent of regional water consumption; by 2000, they are projected to account for about 50 percent.

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[1] See Appendix A for a discussion of the methodology and assumptions used to generate estimates of future trends.

[2] One million gallons per day equals 1,122 AFY. Thus Region 6 consumption is about 25 MMAFY.

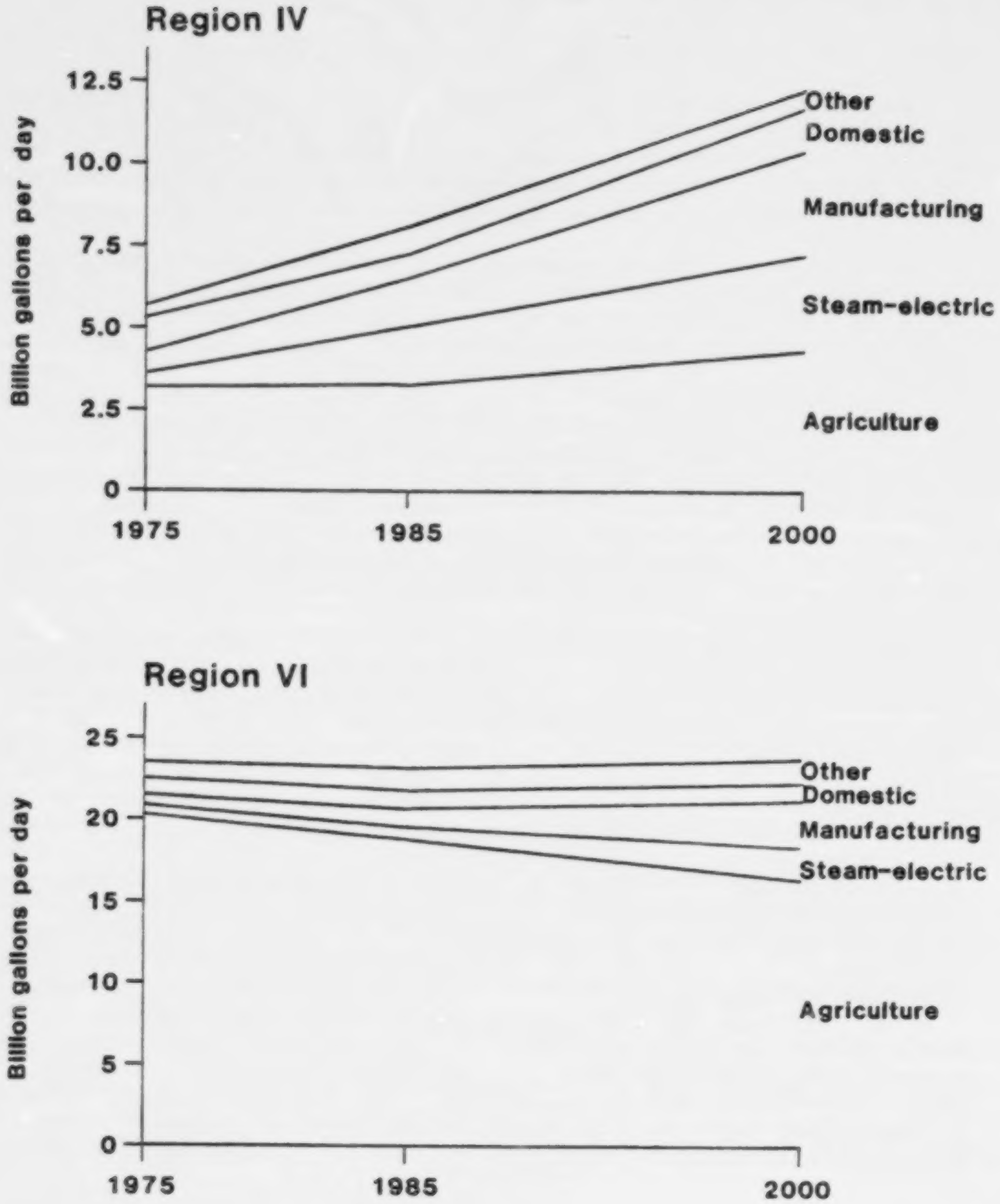

Figure 13-5: Projected Water Consumption in the Sunbelt

Source: U.S., WRC, 1978b.

TABLE 13-7: WATER CONSUMPTION IN REGION 6, 1975 and 2000 (billions of gpd)

State	Year	Agriculture	Steam Electric	Manufacturing	Domestic	Other	State Total
Arkansas	1975	1.57	.01	.05	.05	.03	1.71
	2000	1.95	.06	.19	.06	.04	2.30
Louisiana	1975	1.30	.04	.25	.23	.34	2.16
	2000	1.08	.16	.82	.26	.48	2.80
New Mexico	1975	2.43	.03	.02	.07	.10	2.65
	2000	2.04	.02	.04	.08	.14	2.32
Oklahoma	1975	.97	.04	.04	.10	.10	1.25
	2000	.97	.22	.09	.12	.13	1.53
Texas[a]	1975	14.23	.18	.57	1.04	.57	16.59
	2000	10.88	1.03	1.93	.58	.71	15.13
Total	1975	20.50	.30	.93	1.49	1.14	24.36
	2000	16.92	1.49	3.07	1.10	1.50	24.08
Percentage Change 1975-2000		-17%	524%	250%	21%	32%	2%

Source: Shepherd *et al*., 1980, Appendix C, Table C.2.

[a] Data for Texas (1975) for steam electric, manufacturing, and domestic uses have been updated by data from the State of Texas, Department of Water Resources (1981). Therefore, these data do not correspond to those found in Shepherd *et al*. (1980).

TABLE 13-8: WATER CONSUMPTION IN REGION 4, 1975 and 2000
(billions of gpd)

State	Year	Agriculture	Steam Electric	Manufacturing	Domestic	Other	State Total
Alabama	1975	.04	.03	.19	.05	.03	.34
	2000	.07	.51	.58	.07	.05	1.28
Florida	1975	2.56	.02	.12	.30	.10	3.10
	2000	3.20	.17	.73	.48	.17	4.75
Georgia	1975	.16	.04	.07	.14	.04	.45
	2000	.28	.40	.44	.19	.07	1.38
Kentucky	1975	.05	.05	.09	.05	.06	.30
	2000	.09	.35	.20	.06	.09	.79
Mississippi	1975	.28	.01	.05	.08	.03	.45
	2000	.35	.11	.22	.09	.04	.81
North Carolina	1975	.09	.04	.05	.16	.03	.37
	2000	.15	.44	.29	.24	.04	1.16
South Carolina	1975	.03	.04	.05	.07	.02	.21
	2000	.03	.35	.27	.09	.03	.77
Tennessee	1975	.05	.03	.13	.06	.03	.30
	2000	.06	.47	.45	.08	.05	1.11
Total	1975	3.26	.26	.75	.91	.34	5.52
	2000	4.23	2.80	3.18	1.30	.54	12.05
Percentage Increase 1975-2000		30%	977%	324%	43%	59%	118%

Source: Shepherd et al., 1980, Appendix C, Table C.2.

Nationwide, withdrawals of water for manufacturing are projected to decline over the next two decades. However, in the Sunbelt, it is projected to increase. By the year 2000, the South Atlantic-Gulf region is projected to become the largest water using region in both withdrawals and consumption. In 1975, this region ranked fifth in water withdrawals, with only 8 percent of total manufacturing withdrawals. Two growth factors contribute to this projection: (1) the region is expected to continue to experience rapid population growth; and (2) the major projected growth industries have high consumption rates and produce waste waters that are less recyclable than most other water intensive industries. The Texas-Gulf region is projected to be third in water consumption by 2000 (U.S., WRC, 1978b, pp. 42-44).

Specific information on manufacturing water use and growth trends is presented in Table 13-9. Four key industries--chemical and allied products, primary metals, paper and allied products, and petroleum and coal products were estimated to account for 86 percent of fresh water consumption and 81 percent of withdrawals in 1975. These four industries are already among the most important industries in the Sunbelt and are projected to continue to grow through the year 2010. Except for petroleum and coal products, these industries are projected to grow faster in Region 6 than in Region 4. In terms of absolute earnings, primary metals and paper and allied products are more significant to Region 4 than Region 6.[1]

Estimates of water use by the chemical industry in the four main water resource regions where it is located are presented in Figure 13-6. Except for the Texas-Gulf region, fresh water withdrawals are expected to show a dramatic reduction through the year 2000. These reductions can be attributed to large-scale use of saline water and intensive recycling of fresh water, in part to comply with the Clean Water Act (see Chapter 14). As the industry continues to move toward recycling, more than half of the withdrawals nationwide are projected to be in the Texas-Gulf, Lower Mississippi, and South Atlantic-Gulf regions (U.S., WRC, 1978b, pt. 3, p. 45).

In contrast to reductions in withdrawals, consumption in the chemical industry is projected to increase. This projection can be attributed to the increased use of evaporative holding ponds to meet the Clean Water Act goals and increased production levels. As shown in Table 13-10, water consumption in the Texas-Gulf region is expected to increase by over 400 percent by the year 2000, accounting for 38 percent of the industry's water consumption.

Similar trends are evident for paper manufacturing, primary metals, and petroleum refining. That is, water withdrawals in

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[1] For an elaboration of these trends, refer to Chapter 4.

TABLE 13-9: MANUFACTURING WATER USE AND GROWTH PROJECTIONS

Industry	Water Use[a] Gross Water Use, 1975 (billion gpd)	Water Use[a] Percent of Manufacturing Fresh Water Withdrawals, 1975	Projected Growth (earnings)[b] Percentage Change: 1978-2010 Region 4	Projected Growth (earnings)[b] Percentage Change: 1978-2010 Region 6
Chemicals and Allied Products	40.1	26	+208	+338
Primary Metals	28.2	34	+220	+381
Paper and Allied Products	26.1	16	+170	+241
Petroleum and Coal Products	23.7	5	+360	+153
Food and Kindred Products	4.5	5	+116	+144
Transportation Equipment	3.7	3	+233	+226
Textile Mill Products	1.7	1	+104	+197
All Other Manufacturing	8.6	10	NC	NC

NC = Not calculated.

[a] Data taken from U.S., Water Resources Council, 1978b, pt. 3, pp. 43-51. See Appendix for an overview of the methodology and assumptions of the Second National Water Assessment.

[b] Calculated from U.S., Dept. of Commerce, BEA, 1980. These data are taken from Tables 4-3 and 4-4, Chapter 4, of this report.

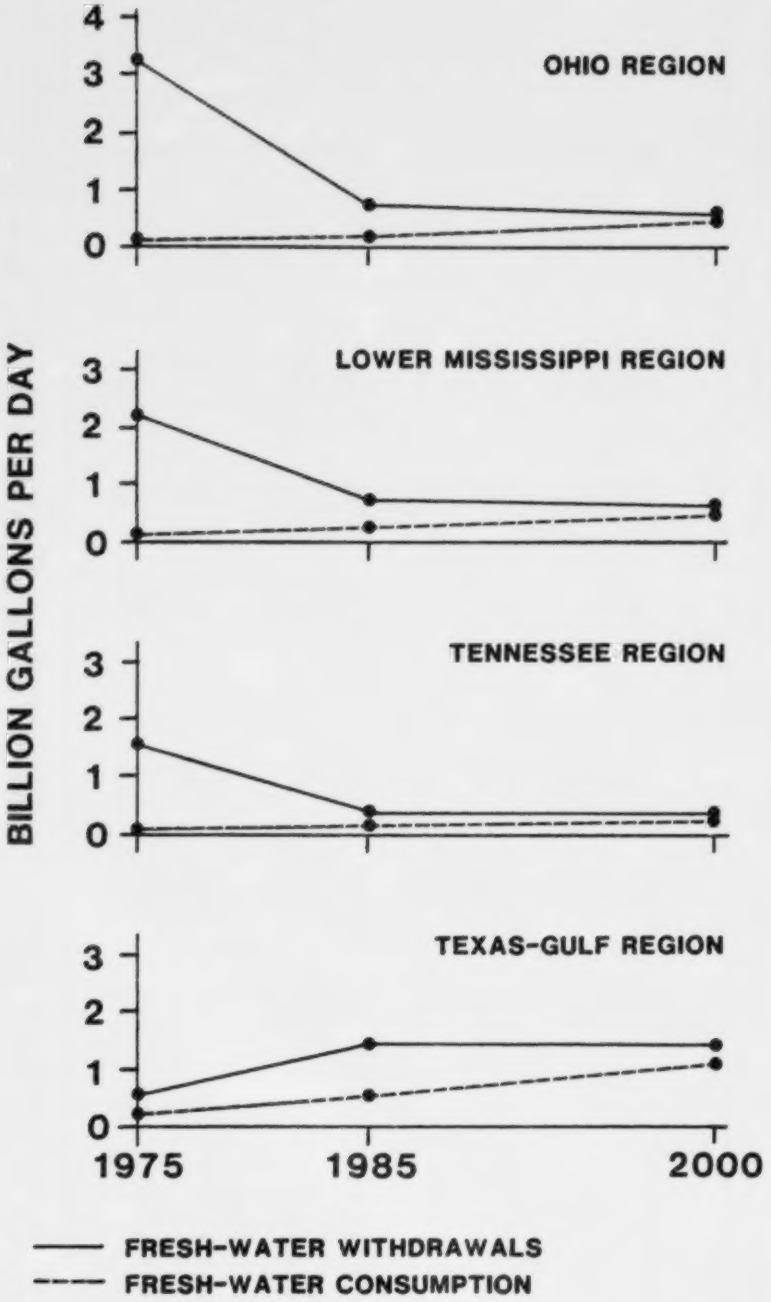

Figure 13-6: Water Use by the Chemical Industry, 1975-2000

Source: U.S., WRC, 1978b, pt. 3, p. 47.

TABLE 13-10: WATER USE BY MAJOR INDUSTRIES IN KEY RESOURCE REGIONS, 1975-2000
(millions of gpd)

Industry/Region	Withdrawals 1975	Withdrawals 2000	Withdrawals Percent Change	Consumption 1975	Consumption 2000	Consumption Percent Change	Percent of National Consumption 2000[a]
Chemicals							
South Atlantic-Gulf	870	748	-14	165	589	+256	14
Ohio	3,261	593	-82	168	464	+176	11
Tennessee	1,520	336	-78	81	262	+223	6
Lower Mississippi	2,251	635	-72	141	504	+257	12
Texas-Gulf	586	1,448	+147	271	1,551	+472	38
Primary Metals							
South Atlantic-Gulf	270	145	-46	51	115	+125	4
Ohio	6,346	1,050	-83	467	834	+ 79	31
Tennessee	77	33	-57	12	25	+108	1
Lower Mississippi	535	101	-81	29	46	+ 59	2
Texas-Gulf	588	162	-72	60	129	+115	5
Paper							
South Atlantic-Gulf	2,111	1,875	-11	262	1,492	+469	36
Ohio	224	133	-41	23	101	+ 77	2
Tennessee	381	246	-35	41	196	+378	5
Lower Mississippi	517	381	-26	46	304	+560	7
Texas Gulf	245	218	-11	38	174	+357	4
Petroleum Refining							
South Atlantic-Gulf	28	25	-11	12	20	+ 67	2
Ohio	114	48	-58	23	38	+ 65	4
Tennessee	0	0	0	0	0	0	0
Lower Mississippi	441	150	-66	66	119	+ 80	12
Texas Gulf	312	479	+54	170	382	+125	39

Source: Data compiled from U.S., Water Resources Council, 1978b, pt. 3, pp. 46-51. See Appendix A for an overview of the methodology and assumptions of the Second National Water Assessment.

[a] This column reflects the amount of water consumed by each industry for each particular region as a percentage of the water consumed by that industry in all 21 U.S. Water Resource regions (nationwide consumption).

these industries are projected to decline in response to recirculation practices and the use of saline water. An exception to this pattern is petroleum refining in the Texas-Gulf region; water withdrawals are expected to increase by 54 percent from 1975 to 2000. In contrast, water consumption is expected to increase for each of these industries through the year 2000. Both the Texas-Gulf and South Atlantic-Gulf regions are expected to experience large consumptive water increases for each major industrial user; for example, consumption in paper manufacturing is expected to increase over 450 percent by 2000.

13.3.2 Problems and Issues

Several water availability concerns will be important to the future development of the Sunbelt. Four categories of problems and issues which appear to be particularly significant will be discussed below: ground water depletion, region-wide surface water availability, completion of the Tennessee-Tombigbee Waterway, and limitations of water management capabilities. These four categories have been selected as among the most important water concerns, based on three criteria: (1) they affect more than one state; (2) they present serious economic or environmental concerns; and (3) they are likely to have long-term consequences to growth in the region.

A. Ground Water Depletion

Ground water is a significant resource--nationwide it is estimated that there is far more ground water available than surface water (U.S., WRC, 1978b, p. 11). However, in many areas ground water resources have experienced long-term excessive uses. As shown in Figure 13-7, areas where ground water has been mined (pumped in excess of recharge) include large portions of New Mexico, Oklahoma, and Texas; along the Lower Mississippi region in Arkansas, Mississippi, and Louisiana; and along the coast of North Carolina. In addition, specific problems are particularly noticeable in southeastern Texas, Florida, and parts of Alabama.

Several problems can result from ground water overdraft. Land subsidence is common in many of these areas. For example, in the Houston-Galveston area, a foot or more of subsidence occurred in over 2,400 square miles from 1954 to 1973, causing abandonment of housing divisions, and over 30 million dollars of damage (Grabrysch, 1976, pp. 16-24). Municipalities depending on ground water have faced water shortages and increased pumping costs. Pumping of fresh ground water can cause salt water intrusion and gradual reduction of surface flows in downstream reaches.

One issue regarding these threats to ground water is the adequacy of state management systems. Table 13-11 indicates the

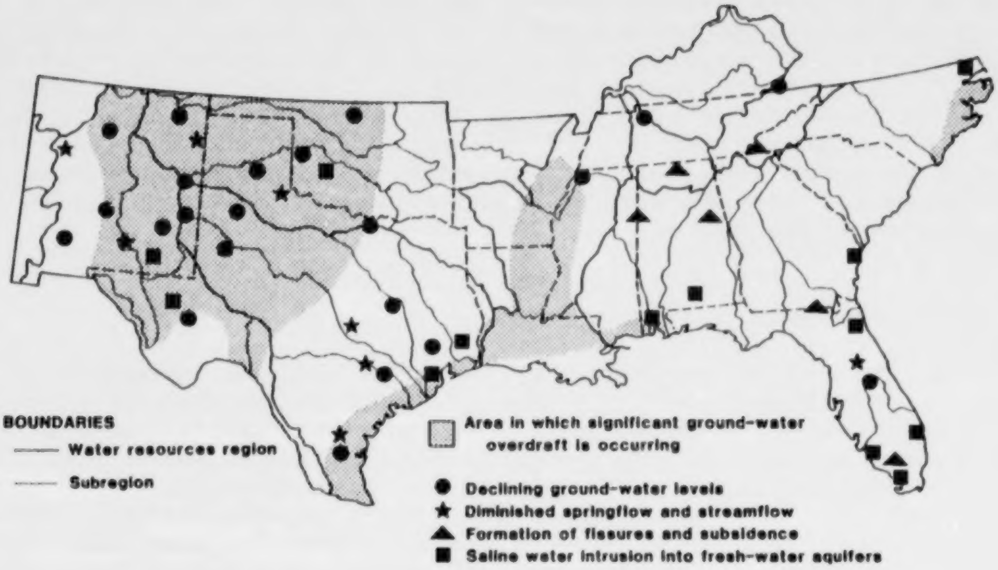
BOUNDARIES
Water resources region
Subregion
Area in which significant ground-water overdraft is occurring
Declining ground-water levels
Diminished springflow and streamflow
Formation of fissures and subsidence
Saline water intrusion into fresh-water aquifers

Figure 13-7: Ground Water Overdraft and Related Problems

Source: U.S., WRC, 1978b, pt. 2, p. 12.

extent of permit procedures in the 13 Sunbelt states. This information indicates that few states have developed ground water management systems, largely reflecting the historical abundance of the resource. Only three states have a statewide permit system (Georgia, Kentucky, and Oklahoma). In each of these states, either domestic or agricultural uses (or both) are exempt from permit requirements.

Ground water can also be managed by designating critical areas where the available supply is being rapidly depleted or where continued withdrawals could lead to contamination through the intrusion of brackish water. Once areas are designated, a state, local, or regional agency can be empowered to regulate ground water use by establishing maximum pumping rates, apportioning the existing supply, closing the aquifer to new uses, or scheduling uses. Four states (Florida, Louisiana, New Mexico, and Texas) have such designated areas and four others (Mississippi, North Carolina, Oklahoma, and South Carolina) are authorized to establish such areas. Conjunctive management--the recognition of

TABLE 13-11: GROUND WATER MANAGEMENT IN SUNBELT STATES

	Permit Procedures			
State	None	Statewide Permit System	Designated Management Areas	Conjunctive Management
Alabama	X			
Arkansas	Governor's Task Force on Water Policy studying alternative management systems.			
Florida			Five regional management districts regulate surface and ground water through permit system.	Dept. of Environmental Regulation emphasizes conjunctive management in State programs.
Georgia		Permit required from Environmental Protection Div. for withdrawals in excess of 100,000 gal/day; agriculture exempt.		
Kentucky		Permit required from Dept. of Natural Resources for withdrawals in excess of 10,000 gal/day; domestic and agriculture exempt.		
Louisiana	X		Ground water conservation district regulates use in five-parish capital area.	
Mississippi			Board of Water Commissioners authorized to designate capacity use areas and regulate use.	

(continued)

TABLE 13-11: (Continued)

	Permit Procedures			
State	None	Statewide Permit System	Designated Management Areas	Conjunctive Management
New Mexico			State Engineer authorized to designate distinct ground water basins and manage use; 29 basins designated	Ground water use may not impair surface water rights.
North Carolina			Environmental Management Commission authorized to designate capacity use areas and regulate use.	Conjunctive management employed in capacity use areas.
Oklahoma		Permit required from Water Resources Board; domestic uses exempt.	Well spacing and metering may be required to protect the safe yield of declining aquifers	Emphasis in state planning on conjunctive management.
South Carolina			Water Resources Commission authorized to designate capacity use areas and regulate use.	
Tennessee	X			
Texas	X		Five ground water districts regulate use; controls on withdrawals in Harris-Galveston Coastal Subsidence Dist.	Dept. Water Resources studying conjunctive management; surface water being developed to replace some ground water use.

Source: U.S., WRC, 1981.

surface and ground water interrelations and coordination of their use--can also be used to improve state management capacity. Four states (Florida, New Mexico, North Carolina, and Oklahoma) have such systems and Texas is studying its applicability.

The following discussion highlights ground water problems for three areas: the High Plains states affected by the Ogallala Aquifer, southeastern Florida, and the Brunswick and Savannah areas of the South Atlantic Gulf.

1. Depletion of the Ogallala Aquifer. The Ogallala Aquifer runs throughout the High Plains states of Nebraska, Kansas, and Colorado and three Sunbelt states--Oklahoma, New Mexico, and Texas (see Figure 13-8). The Ogallala Formation contains approximately 2 billion acre-feet of water (about 650 trillion gallons). However, over most of the area, water is being withdrawn for irrigation in quantities considerably in excess of the natural recharge rate--by as much as 25 times the recharge rate in Texas and Oklahoma. Irrigation wells have increased dramatically in the Oklahoma Panhandle and declining water table problems are evident throughout the area. For example, as shown in Figure 13-9, the water table in Hale County in the Texas Panhandle has been declining steadily since the early 1960's.

Significant advantages have resulted from the use of this ground water. From 1950 through the mid-1970's, irrigated agriculture increased at an average rate of 8 percent per year.[1] Over 16 million acres of food and fiber crops are irrigated in the High Plains from this ground water, and this activity developed into the dominant economic sector in the High Plains. Between 1954 and 1973, feed grain production in Oklahoma, Texas, and Kansas increased 275 percent, spurring the development of the feedlot industry. By 1973, the High Plains region was producing 40 percent of the beef marketed in the U.S. Associated industries producing irrigation equipment, farm machinery, chemicals, and processing plants also grew because they were necessary to support the region's agricultural economy.

This economy depends heavily on the Ogallala, but ground water overdraft has been increasing for years--the annual overdraft exceeds 14 MMAFY (12.5 billion gpd) equaling the natural flow of the Colorado River. Since many locations, particularly in the southern High Plains, have negligible recharge, exhaustion of the water supply could occur within 10 years. In addition, the costs of pumping have soared. In 1977, the cost of electricity to pump one

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[1] Much of the following information is taken from The High Plains Study (U.S., Dept. of Commerce, 1980). This 6 million dollar study is intended to examine alternatives to promote the economic vitality of the High Plains Region.

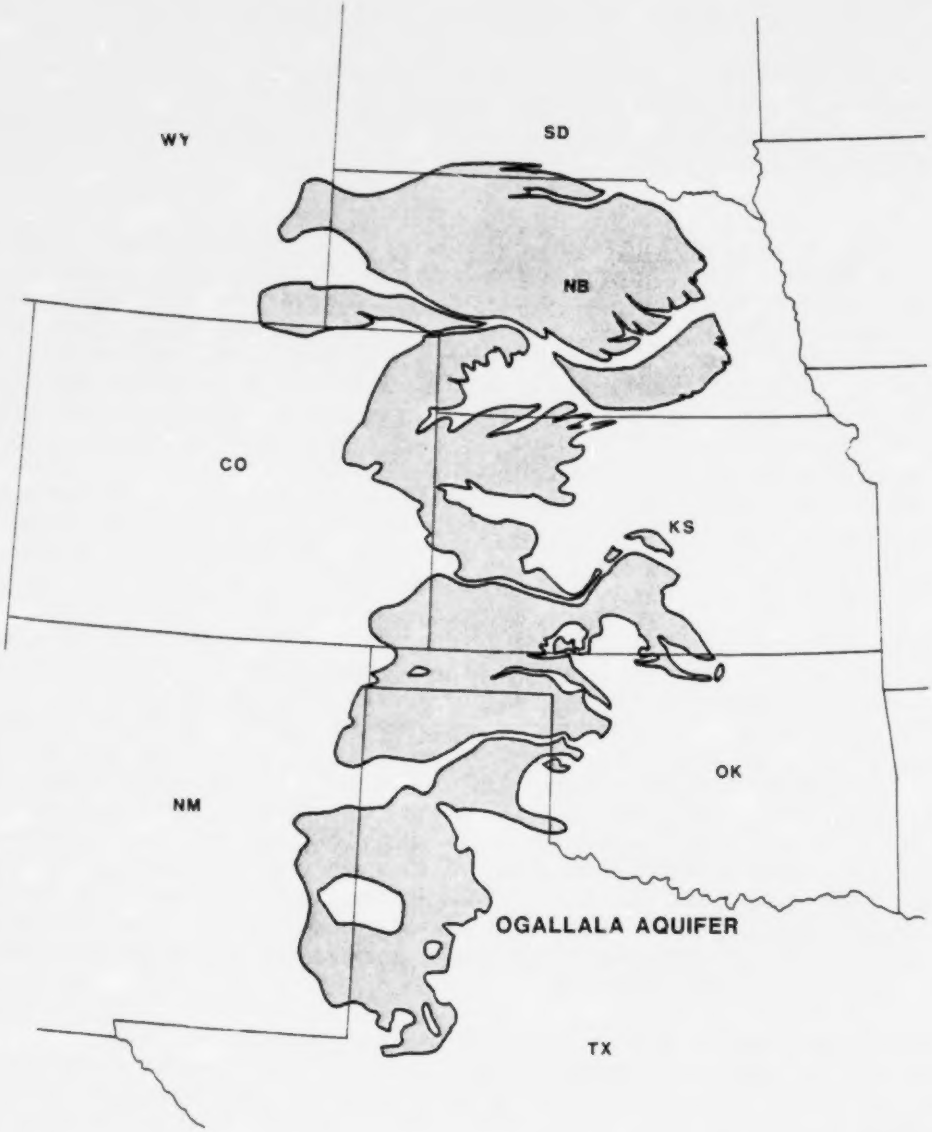

Figure 13-8: The Ogallala Aquifer

Source: McGuinness, 1964.

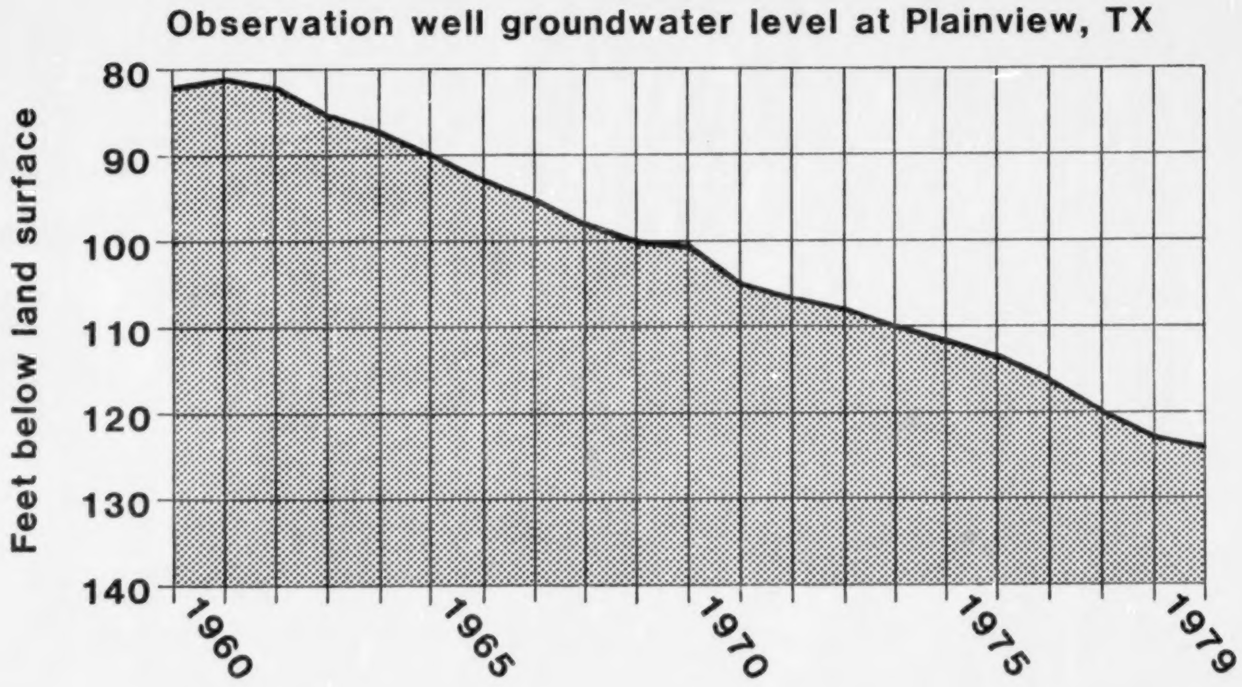

Figure 13-9: Ground Water Mining, Ogallala Aquifer, Hale County, Texas

Source: Texas, Dept. of Water Resources, 1980.

acre-foot of irrigation was about 17 dollars. By 1992, the cost is projected to be about 64 (1977) dollars due to increasing energy costs and declining water tables. This will affect national food supplies and the regional economy. Thus, a range of augmentation and conservation alternatives are being assessed for dealing with the depletion of the Ogallala.

2. Water Problems in Southeastern Florida. The Biscayne Aquifer, recently designated by EPA under the Safe Drinking Water Act of 1974 as the sole source of potable water for over three million people in southeastern Florida (EPA Journal, 1980), underlies nearly all of Dade County, parts of Broward and Palm Beach counties, and much of the Everglades (see Figure 13-10). Under normal conditions, the aquifer is highly productive with well yields typically exceeding 3,250 AFY (2.9 million gpd). However, both the quantity and quality of water in the aquifer are threatened.

Since rainfall provides most of the aquifer's recharge, low flows during seasonal dry periods or dry years have resulted in overdrafts by agricultural and domestic users, thus permitting salt water intrusion into water wells in the greater Miami area. For example, the average rainfall of 50 to 60 inches per year provides sufficient water, but in dry years only half that may fall. During a drought in 1971, eight of Miami's wells had to be shut down because overdrafts resulted in saltwater intrusion (Carter, 1976). In addition, there is considerable variation in precipitation over the course of a year, with the critical low for the year usually occurring by the month of May. In 1975, agricultural withdrawals of 7.5 MMAFY (6.7 billion gpd) in May were twice that for January (U.S., WRC, 1978b).

Despite past efforts by Dade County authorities to implement water and growth management practices, urbanization has been largely uncontrolled. Urban development now blankets the northeastern corner of Dade County and growth has recently spread five to ten miles west of the coastal ridge into the eastern edge of the Everglades, encroaching upon the vital recharge areas of the aquifer (Greene, 1979). This area will continue to have a growth management problem. The population in Dade County is expected to increase by one-third over the next 20 years (Smith, 1980). Since the carrying capacity of the aquifer is fixed, it seems likely that south Florida will be faced with even more critical water shortages and contamination problems.

3. Depletion of Ground Water in Brunswick and Savannah. Despite ample rainfall in the eastern half of the Sunbelt, some urban areas on the coastal plain find quality water resources in short supply. In several cities, water tables have been lowered, and saltwater intrusion has made the water unsuitable for public

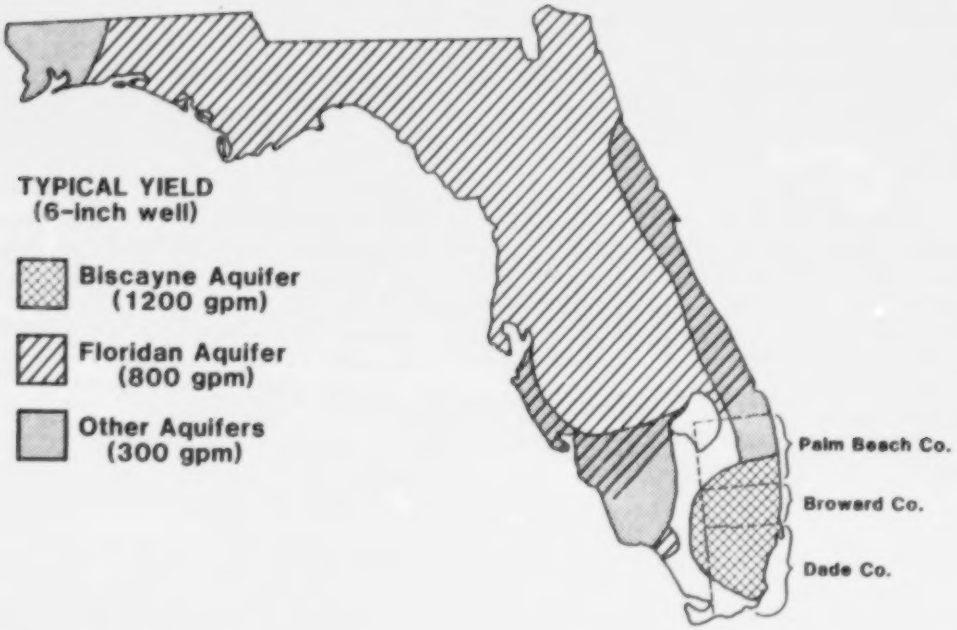

Figure 13-10: Principal Sources of Ground Water in Florida

Source: Parker, Odum, and Cooley, 1981.

and industrial use. Without improved water management policies, fresh ground water supplies are expected to become increasingly scarce in the future.

In Brunswick, Georgia, saltwater intrusion began in the 1940's. Since that time, five of the city's wells have been closed because of saltwater contamination (Neal, Jackson, and Lowry, 1980). Although additional wells have been drilled, they are also threatened by saltwater intrusion. Three industries account for 90 percent of the 125,000 AFY extracted from the principal aquifer in the Brunswick area (Neal, Jackson and Lowry, 1980). Several industries in the area have volunteered to cut back their water use; for example, Brunswick Pulp and Paper Company plans to reduce water withdrawal from 75,000 to 64,000 AFY (67 to 57 million gpd) over the next decade. The Hercules Chemical Company has cut consumption in half and plans to further reduce water use from 20,000 AFY to 14,000 AFY (Neal, Jackson, and Lowry, 1980).

The area around Savannah, Georgia, is similarly threatened by a lowering of the water table in their Principal Artesian Aquifer, resulting in lowered water pressure and saltwater intrusion. Saltwater intrusion under Savannah has already left wells dry on Hilton Head Island, South Carolina. If water consumption in Savannah increases 22,000 AFY (20 million gpd) in the near future, ground water may face depletion by the turn of the century (Neal, Jackson, and Lowry, 1980).

Savannah has a larger population than Brunswick and state and local officials are trying to attract new industries to the area. The coast offers industries many advantages, and presently there are 11,500 acres in Savannah zoned for heavy industrial use. Water problems in the coastal plain areas of Georgia are compounded by recent increases in irrigated agriculture, largely from ground water. Functioning irrigation wells in the state have increased 55 percent per year recently (Prunty and Brandhorst, 1980). The total irrigated acreage in the state nearly doubled from 1975 to 1977 (Kundell, 1978).

B. Region-Wide Surface Water Availability

As has been suggested throughout this chapter, adequacy of water supplies to meet expanding industrial and population needs is already a concern in many parts of the study area. Figure 13-11 shows broad areas where water availability problems already exist or are projected to occur by the year 2000 (U.S., Water Resources Council, 1978b, pt. 2, pp. 3-14). Problems include both inadequate streamflow and ground water overdraft. Several site-specific water supply problems also exist throughout the Sunbelt but are not shown in this figure.

This overview reflects the conventional wisdom that water availability is a well-recognized problem throughout Region 6, but is often not considered a general problem in Region 4. One important factor which challenges this notion is the relationship between water quality and water availability; many studies on future water availability do not adequately consider this relationship. Figure 13-12 indicates areas experiencing water quality problems from point and nonpoint source pollution of surface water and ground waters (see Chapter 14). Areas experiencing multiple water quality impacts include the Gulf coast from Galveston, Texas, through Mobile Bay, Alabama, to the west coast of Florida, the coast of North Carolina, and several areas throughout Kentucky. This information suggests that water availability may well be a problem in the Southeast since water quality degradation could limit the future uses of water, especially for domestic purposes.

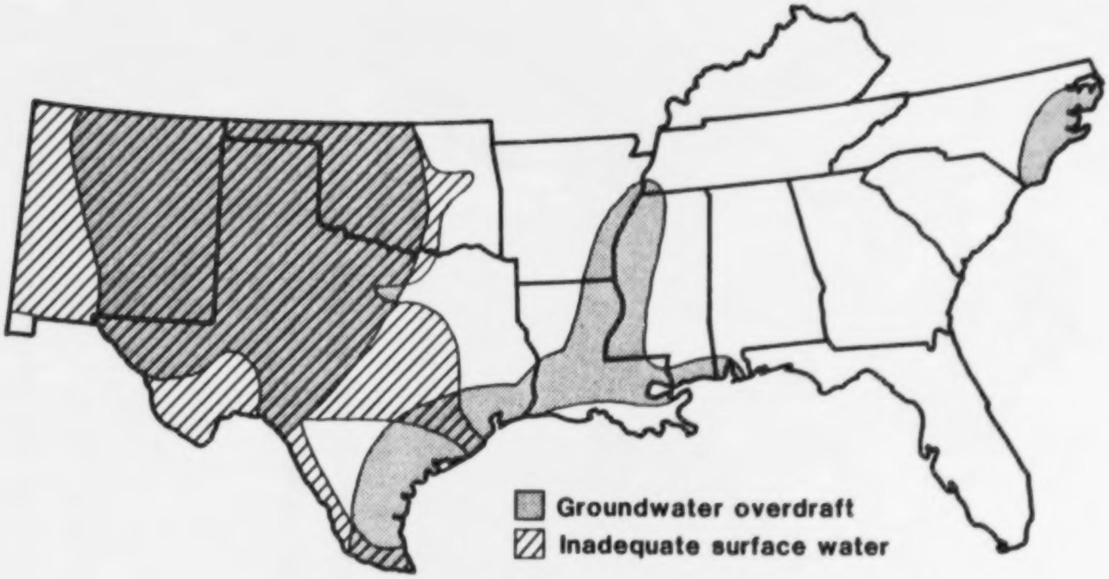

Figure 13-11: Current Region-Wide Problems: Water Availability

Source: Adapted from U.S., WRC, 1978b, pt. 2, pp. 3-14.

There are many sources of these pollution problems.[1] Most surface water point sources of pollution are municipal or industrial. Coliform bacteria from municipal waste or feedlot drainage and nutrients from municipal and industrial discharges constitute the majority of the point source problems. Polychlorinated biphenyls, polybrominated biphenyls, polyvinyl chloride and related industrial chemicals, heavy metals (mercury, zinc, copper, cadmium, lead, etc.), and heat from manufacturing and power generation are the other identified point sources of pollution.

Most nonpoint sources of pollution are irrigation runoff with high concentrations of dissolved solids, pesticides and other agricultural chemicals, and urban runoff. Mine drainage is a problem mainly in Kentucky, Tennessee, and northern Alabama and saltwater intrusion is a nonpoint problem mainly along the Louisiana and Texas coasts.

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[1] Refer to Chapter 14, Water Quality, for an elaboration of these concerns.

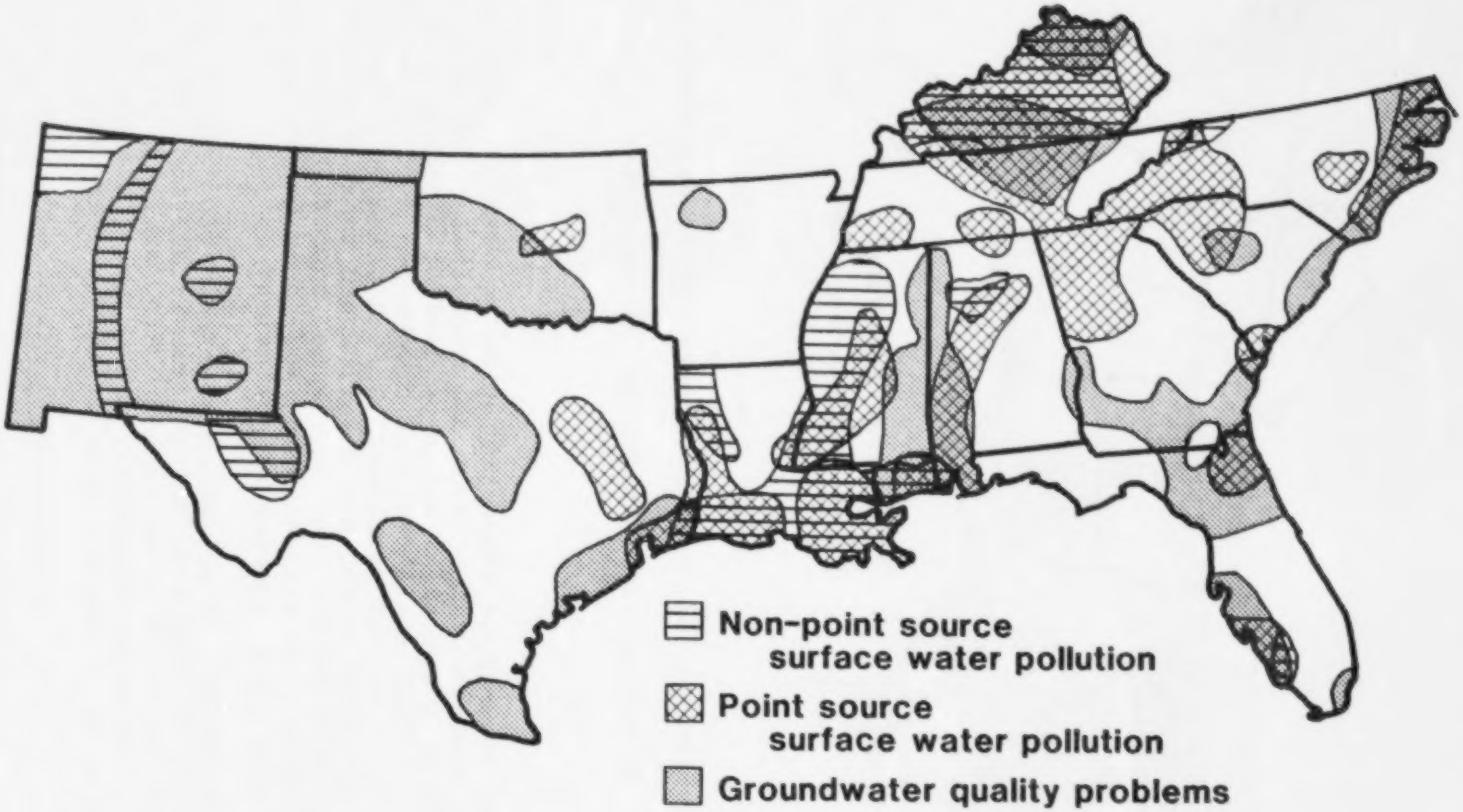
▤ Non-point source surface water pollution
▩ Point source surface water pollution
▒ Groundwater quality problems

Figure 13-12: Significant Water Quality Problems in the South

Source: U.S., WRC, 1978b, Vol. 2, pt. II, pp. 20-21, 30.

Ground water pollution results from both natural and man-made causes. High levels of minerals or other dissolved solids occur in several parts of the study area including New Mexico and west Texas, along the Mississippi-Alabama border and west Florida. Saltwater intrusion occurs along many coastal areas and some inland areas such as central Texas from overpumping. Specific sources of ground water pollution include municipal and industrial wastes, landfill leachate, irrigation return waters, wastes from well drilling, and the well injection of industrial waste liquids.

In addition, increased competition for water will occur in many areas already experiencing multiple water quality problems. As identified in Section 13.3.1, this includes growth of the chemical industry in the Texas Gulf Coast and South Atlantic-Gulf regions, primary metals in Kentucky and Tennessee, paper products in the South Atlantic-Gulf, and petroleum refining in the Texas Gulf and Lower Mississippi regions. In the Texas Lignite area, significant increases in electric power generation will increase the stress on water resources which are already scarce and affected by water quality impacts (see Chapter 6). Increased agricultural production for food export and biomass development is expected to occur in many parts of the study area (see Chapter 9), and rapid population increases are projected in Florida, Texas, and along most of the Gulf coast (see Chapter 3).

Increased competition for water and water quality protection will be important factors to most Sunbelt states by the year 2000. Water resource limitations could force restrictions in the level of growth, including growth of the energy industry in Texas and expansion of the chemical industry in the South Atlantic-Gulf region. In order to avoid limitations on desired growth and to preserve adequate quality of water resources, states and other levels of government, working in concert with private sector interests, will need to enhance their capacity to manage water resources. Of primary concern in this regard will be the need for states to consider modifications of riparian water doctrines, which create several barriers to allocating scarce water resources among competing demands, and to improve their capability to manage quality and quantity aspects of the resource in an integrated fashion (see Section 13.3.2D below).

C. The Tennessee-Tombigbee Waterway

The Tennessee-Tombigbee (Tenn-Tom) Waterway is intended to provide a 232-mile navigation channel from Demopolis, Alabama to the Tennessee River (see Figure 13-13). This channel is divided into three sections: a 148-mile portion that lies within the Tombigbee River; a 44-mile section which will parallel the East Fork of the Tombigbee; and a 40-mile divide cut which will connect the Black Warrier-Tombigbee Waterway which runs south to the port of Mobile. The Tenn-Tom was first authorized in 1942 and funded in

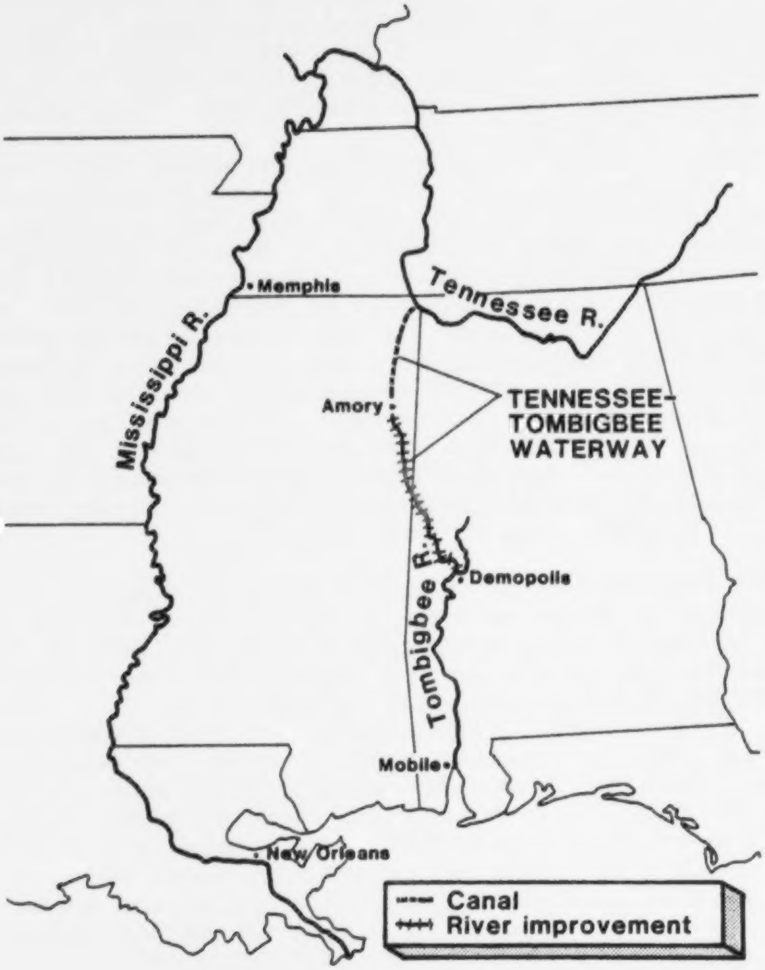

Figure 13-13: Tennessee-Tombigbee Waterway

Source: Smith, 1981, p. 741.

1971. The waterway, now more than half finished, is scheduled for completion in 1988. Current estimates of the total costs are at about 2 billion dollars, compared to estimated costs of 323 million dollars in 1971 (Smith, 1981).

The major benefit of the waterway is to provide a more efficient and economic transportation route from the midcontinent and eastern U.S. to the Gulf of Mexico. This may be particularly valuable with increased coal production and trade. In addition, recreation, fish and wildlife, and area development benefits have been identified (U.S., GAO, 1981, p. 5). As has been true for virtually every recent water development project, controversy has emerged over whether these benefits outweigh the costs of the project. In 1971, when construction of the project was approved, the Army Corps of Engineers estimated the benefit/cost ratio to be 1.6 to 1. A restudy for the Corps in 1976 reduced the benefit/cost ratio to 1.08 to 1. Estimates of both the benefits and the costs have been subject to considerable controversy, as has been the question of the appropriate discount rate (Morris, 1980; Pfrommer, 1980). The General Accounting Office found that several potential beneficiaries of the project were no longer in existence (U.S., GAO, 1981), and the Congressional Research Service determined that the waterway might not have any advantage over the Mississippi (Thompson, 1981).

Rather than continue the endless debate over cost/benefit ratios, which have not helped to solve the controversy over the Tenn-Tom, a more productive policy would be to recognize that adverse environmental consequences would result from the waterway. If the political decision is made to complete it, plans should include measures to mitigate or avoid the adverse consequences. These include water quality degradation, effects on ground water, and ecological problems.

Two concerns have been raised about water quality (U.S., Army Corps of Engineers, 1971):

- Waste assimilation capacity of existing streams will be greatly reduced when streams are replaced by navigation pools. The reduction could result from channelization and cutting off river bends, and the associated loss of natural shallow water areas, floodplains, riffles, and the aquatic vegetation in each area; and

- The portion of the Tennessee River which will supply water to the Tenn-Tom is influenced by heavy industrialization and contains relatively high levels of nutrients, heavy metals, and organic toxicants.

Impacts of the Waterway on ground water resources is more uncertain than for surface waters. Although portions of the river section and the canal section may serve as sources of ground water recharge, the 175-foot deep divide cut will act as a drain for aquifers in the area. This includes an artesian aquifer in the lower region of the cut. A cut of 40 feet has previously been made in this area without adverse effects, but the magnitude and areal extent of the Waterway cut is not certain (U.S., Army Corps of Engineers, 1971). The potential for damages to ground water resources led Representative Jamie Whitten (D, Mississippi), to introduce a bill which would provide relief for losses of water supply due to the Tenn-Tom.

Ecological impacts include loss of terrestrial, riparian, and aquatic habitat. The project will require the commitment of 70,000 acres of land for construction and subsequent operation and maintenance. About 40,000 acres will be completely inundated. Of the total committed land area, 13,000 acres are classified as pasture and croplands. Approximately 56,000 acres are forested, with 31,000 acres consisting of bottomland hardwoods or other suitable wildlife habitat (U.S., Army Corps of Engineers, 1971). In addition, areas not directly impacted by construction of the Waterway may be subject to waterlogging of the soil and resultant changes in the plant and animal communities (Claflin, 1980).

Impacts on fish and wildlife resources along the Waterway can be mitigated (U.S., Army Corps of Engineers, 1971). The Corps has created an aquatic-terrestrial interface along the canal section to provide 75 miles of 'edge' that could be managed for wildlife and recreation opportunities. In addition, the Tennessee-Tombigbee project may provide intermittent flooding for waterfowl areas managed by the state of Mississippi. No specific mitigation proposals entailing federal responsibilities were included in the environmental statement. In the ten years since the initial analysis, the Fish and Wildlife Service and the Army Corps of Engineers have developed a series of mitigation alternatives, but none have been implemented and there is no Congressional authorization for land acquisition for the purposes of mitigation (Claflin, 1980; Blackwelder, 1979). For mitigation of the extensive loss of diverse habitat types, the Army Corps of Engineers is relying on the creation of 40,000 acres of lake fishing area and a potential tailwater fishery in the canal section.

D. Water Management Capabilities

Much of the discussion in this chapter suggests that there will be an increasing need for water resource management in the Sunbelt. In the Southwest, this need already exists because the area is water short and it will face increasing pressures from energy development, population growth, and expansion of industries such as chemical and pulp and allied products. In the Southeast, the need for water management has been less apparent. In fact, historical water abundance in this area has led to the widespread use of the riparian water system which allows relatively uncontrolled water withdrawals. However, increased concern over water quality problems in the Southeast and new demands resulting from population growth, primary metals production, paper and allied products, and other industries are likely to create more stress on water resources.

Thus, in many parts of the Sunbelt the availability of adequate water supplies may be an important constraint on growth. For example, municipalities are facing increased responsibilities for provision of water supply and protection of water quality with fewer resources. The rapid metropolitan growth throughout much of the Sunbelt (see Chapter 3) will increase municipal water management problems and limit growth in some areas. Industries which require reliable water supplies may find growth more costly because of the need to develop or transport water, or they may find growth to be impossible in some areas.

Improved water management can be accomplished in a variety of ways, including development of water resources, more efficient water use, improving institutional capacities, and improving information about water resources. Regardless of the specific strategies chosen, it is apparent that states and localities will be primarily responsible for designing and financing new initiatives.[1] In order to meet this challenge, states and municipalities will first need to identify and assess the severity of their problems before they can select water policies appropriate to the growth pressures facing them. Among the specific needs in this regard are the following:

- Assessment of the adequacy of both riparian and appropriation systems for managing water conflicts;
- Assessment of the adequacy of organizational arrangements affecting water resources, including whether fragmented or centralized arrangements are more appropriate;
- Assessment of the adequacy of information bases about water resources, including monitoring of ground water quality, knowledge of current uses of water, and future trends in surface water quality;
- Assessment of the potential for interstate conflicts over surface and ground water resources and whether new interstate arrangements are needed for emerging problems; and

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[1] This trend toward increased state responsibility was begun under the Carter Administration and continues in the Reagan Administration. Garrey Carruthers, Assistant Secretary of Interior for Land and Water Resources, recently said that states would be left to their devices, regardless of cost (Bean, 1981a).

- Assessment of the adequacy of current policies to protect instream flow needs, including hydroelectric power generation, navigation, recreation opportunities, waste assimilation, maintenance of ecosystems, floodplain wetlands, and aesthetic qualities.

Recognition of these needs has been increasing in the Sunbelt. At a recent state water conference, Oklahoma Governor Nigh stated that "water is the major issue of the '80s" (Bean, 1981b, p. 21). In addition, new water management strategies will need to be developed to integrate water quality and water availability concerns. As one example of innovative approaches, El Reno, Oklahoma, a city of 25,000, was faced with state requirements to upgrade its waste treatment plant and the prospect of water shortages in the future. In response, the city developed a total water resource project combining elements of drinking water supply, water conservation, land treatment of wastewater, and agricultural production. Under contract with a local farmer growing crops on 465 acres, the farmer conveys to the city the use of all ground water rights. The city uses the water rights to supply drinking water to its residents. In turn, the city collects all sanitary wastewater, pretreats it, and delivers it back to the farmer in pressure pipelines. The city has furnished, installed, and maintains self-propelled irrigation sprinklers covering at least 465 acres. El Reno also provides the equipment and the necessary technical expertise to analyze samples and data required for monitoring the land treatment system. The monitoring includes measuring the wastewater quality, the ground water quality and direction of flow, and the soil condition, quality, and productivity. The city pays for most of the electrical costs for pumping. The farmer conveys his water rights free of charge, and will pay the city a total of $100,000 during the 20-year contract for the nutrients in the water.

On the state level, Florida has made the most dramatic changes in water policy. Water in Florida has been heavily managed; for example, the State requires permits for water uses, in significant contrast to strict riparian or appropriation doctrines. However, during the past several years, pressures have increased to develop more stringent policies for managing water and protecting water quality. In part, these pressures arose from dissatisfactions with Florida's system of managing water by five dispersed agencies (Crow, 1981, p. 1). The new Florida water policy has several provisions affecting water resources throughout the state, but it also decentralizes authority among water management districts to reflect the variation in the water situation among different parts of the state. Among the most significant provisions of the policy are the following (Crow, 1981, pp. 1-3):

- Water management programs must emphasize conservation of water and encourage the use and reuse of water of the lowest acceptable quality;

- Water management programs must utilize and protect natural water management systems, including wetlands, floodplains, and aquifer recharge areas;

- Water management programs must establish minimum flows to protect water resources and environmental values associated with marine, estuarine, fresh water, and wetlands ecology; and

- Water management programs must encourage nonstructural solutions to water resource problems.

13.4 SUMMARY

Table 13-12 summarizes water availability problems and issues for the Sunbelt. Four problem areas have been identified in this chapter: ground water depletion, region-wide water shortages, completion of the Tennessee-Tombigbee Waterway, and water management capabilities. For each of these categories, Table 13-12 identifies causal factors, the nature and seriousness of the problem, and associated policy concerns.

Two primary conclusions can be drawn from this chapter. First, a number of causal factors will stress the water resources of the Sunbelt. Among the most significant of these are: (1) increased agricultural production throughout Region 6 and in Florida, Georgia, and Kentucky; (2) continuing population increases, particularly in Texas, Florida, and along the Gulf Coast; (3) expanded energy development, particularly in Texas and the Appalachian region; (4) growth of the chemical industry in Texas, Louisiana, and the South Atlantic-Gulf; (5) production of paper products, primarily in Arkansas and the South Atlantic Gulf; (6) primary metals production in Kentucky and Tennessee; and (7) petroleum refining in the Texas-Gulf Coast and Lower Mississippi regions. While none of these factors by themselves will create water shortages, their multiple effects will produce stress on water resources which has not been experienced in most of the Sunbelt.

Second, because of these factors, the possibility for water shortages in much of the Sunbelt by the year 2000 must be taken seriously. Shortages are already common in the Southwest and ground water depletion in the Southern High Plains and Texas-Gulf Coast areas is causing serious economic concern. However, it is often not recognized that such shortages are increasingly likely in the Southeast because of new demands for water and serious

TABLE 13-12: PROBLEM CHARACTERIZATION MATRIX: WATER AVAILABILITY

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problems
Ground water depletion	• Irrigated agriculture • Population growth • Industrial growth - Chemicals - Pulp and paper - etc.	• Economic • Ecological	This is an immediate problem which will worsen over the next decade. It is expected to remain a problem through 2010.	Problem will be pervasive across the Sunbelt with most serious instance occurring in southern High Plains (Ogallala Aquifer), along Texas Gulf coast, and South Atlantic-Gulf (Biscayne Aquifer in Florida, coastal areas of Georgia, S. Carolina).	Economic impacts can be severe, e.g., depletion of Ogallala could influence economy of entire High Plains region. Growth could be restricted in many areas (e.g., Savannah/Brunswick). Adequacy of water for population will be threatened (southern Florida).	Few states have adequate legal/ regulatory structure to protect ground water resources. Intergovernmental cooperation will be required to deal with many ground water problems (e.g., Ogallala).
Region-wide water shortages	• Increased agricultural production • Growth of industry - Chemicals - Pulp and paper - Primary metals - Electric power generation - etc. • Population growth	• Economic • Ecological • Aesthetic	Near-term problem in the Southwest. Long-term problem in the Southeast.	By 2000, water shortages could be pervasive in much of the Sunbelt. New Mexico, Oklahoma, Texas, the Gulf coastal areas of Louisiana and Alabama, and Florida will likely face the most serious problems.	Water shortages could affect the economic growth and population stability of much of the region. In some areas, ecological damage to aquatic ecosystems could be irreversible.	Riparian water laws create many barriers to improved water resource management. Water quality and water quantity concerns are seldom integrated. Few mechanisms for intergovernmental cooperation exist.

(continued)

TABLE 13-12: (Continued)

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problems
Completion of the Tennessee-Tombigbee	• General economic growth (energy, chemicals) • Ecosytem modifications	• Economic • Ecological	Impacts will be long-term after completion of waterway (1990 and beyond).	Localized problem affecting parts of Alabama, Mississippi, Tennessee.	Several benefits result from development, including improved navigation and secondary regional development. Water quality impacts could be serious, including reduced assimilation capacity. Stream habitat will be altered.	Rapidly increasing costs combined with increasing questions about the benefits of the project have threatened cancellation.
Water management	• Rapid expansion of demands for water • Increasing water quality problems • Limitations in existing institutions	• Political • Economic	Immediate problem througout most of Region 6. Likely to become an important need in Region 4 in the 1980's.	Problem will be pervasive across the Sunbelt. Areas likely to feel most immediate need for improved management are New Mexico, Oklahoma, Texas, and states of the South Atlantic coast.	Water is central to the growth capacity of each state. Without improved management, growth could be restricted in several areas.	Revisions in water management capabilities are likely to be most difficult in the eastern part of the Sunbelt where water has historically been abundant. Interstate cooperation to deal with ground water problems and river basin problems may be very difficult. State and local governments will have more responsibility and fewer resources to deal with these problems.

water quality problems in many areas. Ground water depletion in Florida and along the Atlantic Coast will contribute to water availability problems in the Southeast.

Water shortages could be particularly difficult to resolve in many parts of the Sunbelt. In part, this is because much of the region has been traditionally water-rich. Thus, water management systems have not been developed. The riparian system, based on water abundance, creates many barriers to managing a scarce resource. In addition regulatory systems to protect ground water systems and instream values have generally been slow to develop. Virtually no cooperative intergovernmental mechanisms exist for resolving emerging issues affecting multi-state river basins. Thus, one of the most serious questions about economic and population growth in the Sunbelt over the next two decades will be the adequacy of water resources to meet rapidly increasing demands.

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APPENDIX 13A

METHODOLOGY AND ASSUMPTIONS OF THE SECOND NATIONAL WATER ASSESSMENT[1]

The Second National Water Assessment was conducted in three phases: Phase I, Nationwide Analysis; Phase II, Specific Problem Analysis; and Phase III, National Problem Analysis. The approach and assumptions which directly affect the data used in this chapter are summarized below.

Phase I: Nationwide Analysis

Estimates of current and projected water requirements and problems were prepared by the U.S. Water Resources Council member agencies. Estimates were made of water requirements for three scenarios: 1975, 1985, and 2000. These estimates were based on the following assumptions:

- The national population will grow at slightly less than one percent per year and will reach zero growth early in the next century. For the year 2000, this assumes 268 million people;
- The Gross National Product will increase at about four percent per year, doubling by the year 2000;
- The water quality goals of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) will be largely achieved by 1985;
- The attainment of goals for water quality and the higher cost for water will improve water use efficiency;

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[1] For additional information on the approach to the Second National Water Assessment, see U.S., Water Resources Council, 1978. The Nation's Water Resources 1975-2000, Second National Water Assessment, Vol. III: Analytical Data. Washington, D.C.: Government Printing Office.

- Agricultural production and marketing will reflect recent (1971-1973) trends in per capita consumption and export levels;

- Fish and wildlife and recreation needs will continue as they have in the past 10 years; and

- Increased levels of floodplain regulations will reduce dependence on structural measures for flood control.

Phase II: Specific Problem Analysis

Regional sponsors, one for each of the 21 water resources regions, surveyed and analyzed state and regional viewpoints about (1) current and future water problems, (2) conflicts that may arise in meeting state and regional objectives, and (3) problems and conflicts needing resolution.

State-Regional Futures were prepared by regional study teams. Detailed discussions of the assumptions and methodologies used in the State-Regional Futures analyses are provided in technical memos prepared by the study teams. The general framework for each regional study was as follows:

- A problem identification survey based on regional views on population growth, economic activity, and environmental concerns was conducted;

- Problem issues and areas were selected for further evaluation; and

- Information was developed to describe the severity of problem issues within selected problem areas.

Phase III: National Problem Analysis

The Water Resources Council conducted this final phase in three steps: (1) an evaluation of phases I and II; (2) an analysis that identified and evaluated the nation's most serious water resources problems; and (3) the preparation of a final report entitled The Nation's Water Resources--1975-2000.

From the findings of the Nationwide Analysis and the Specific Problem Analysis, the Council identified and evaluated the nation's most serious water resources problems. Where major differences between the Nationwide Analysis and the Specific Problem Analysis appeared, every effort was made to reconcile the differences. If the differences could not be satisfactorily resolved, the differences are cited appropriately in the assessment report.

Data Sources and Federal Agency Responsibilities

The lead federal agency for an assigned task assembled pertinent information, considered the assessment assumptions, developed methodologies to determine present and future conditions, and made the necessary computations and analyses.

There were etremely wide variations in (1) the type of information that was available, (2) the number and scope of assumptions that could or should be applied, and (3) the availability and the applicability of accepted or possible methodologies. Information about these procedures is available from the federal agencies as indicated below:

- Economic and population data: Department of Commerce, Bureau of Economic Analysis
- Land uses, agricultural practices, erosion, flood damage, and recreation requirements: Department of Agriculture, Soil Conservation Service
- Electric power generation: Department of Energy, Federal Energy Regulatory Commission

CHAPTER 14

WATER QUALITY

HIGHLIGHTS

- Status and Trends

    1. Overall water quality in the study area is relatively good, especially when compared to the older industrialized areas of the Northeast and Great Lakes. However, several regions and localized areas do suffer from water pollution, and pressures on water resources will increase as population and economic growth continues.

    2. Municipal discharges seriously affect at least some streams in almost every river basin in the study area. With projected population increases, improved sewage treatment facilities will be needed to achieve a decrease in BOD and nutrient discharges. The federal program for supporting construction of municipal sewage plants is under review due to criticisms of its high costs and inefficiencies.

    3. Industrial waste water discharges have been identified as seriously affecting 74 percent of the river basins in the Southeast region and 70 percent of those in the Southcentral region. Although pollution control efforts in industry have been far more successful than with municipal wastewaters, needed improvements include the pretreatment of industrial wastewaters to remove toxic chemicals before being discharged to publicly-owned treatment plants.

    4. Nonpoint sources of pollution also seriously degrade water quality throughout much of the Sunbelt. In the Southeast region, the most widespread nonpoint sources are urban runoff and agriculture, each seriously affecting about 60 percent of the river basins. Silviculture and individual sewage disposal systems also seriously affect about one-third of the basins. In the Southcentral region, agriculture affects 87 percent of the basins, while urban runoff and mining (including oil and gas production) affect over one-half of the basins.

5. The extent of ground water quality problems and their potential for affecting human health or limiting future use of this resource are not well understood. Important sources of ground water contamination in the Sunbelt include spills of chemicals, oil and gas well drilling, waste disposal, and septic tanks.

6. A recent survey in six states of the Sunbelt of wells which supply drinking water showed significant levels of contamination by chlorinated hydrocarbons. Trichloroethylene, a suspected carcinogen, was the most frequently detected compound and was found in 8 percent of the wells tested.

- Geographic Areas

7. The western region of the study area, which suffers from serious water availability problems, also is impacted by several natural and man-made water pollution sources. Especially important in this region are dissolved solids from agricultural runoff, runoff from feedlots, and poor ground water quality from both natural sources and oil and gas production.

8. Both surface and ground waters have been adversly affected in the Gulf Coast region of Texas and Louisiana by several sources including: toxic pollution from effluents and solid wastes associated with concentrations of industry (especially chemical production); municipal discharges; agricultural runoff; and salt water intrusion due to overpumping of aquifers and reduced flows of surface streams.

9. Acid mine drainage has been identified as a serious problem in Kentucky and Alabama. Soil erosion and nutrients from municipal and industrial point sources are also serious in several locations throughout the Ohio and Tennessee River basins.

10. Threats to ground and surface waters from a variety of sources exist throughout the South Atlantic Gulf area (North and South Carolina, Georgia, Florida, and Alabama). For example, the west coast of Florida is being impacted by nutrients from municipal discharges, effluents from extensive phosphate mining operations, water quality degradation due to hydrologic modifications, and salt water intrusion.

- Key Problems and Issues

11. As water discharge standards become more stringent, the economic costs of controls increase substantially. Thus, it may not be possible to meet existing or planned water quality standards in some areas with concentrated industrial/population growth and/or low stream flows.

12. Water quality standards and monitoring networks do not adequately address toxic pollutants in most states.

13. Although nonpoint source pollution is widespread, no broad-based regulatory program exists and there is considerable uncertainty as to the effectiveness of various control measures (e.g., soil conservation practices and integrated pest management).

14. Despite the high degree of dependence on ground water as a drinking water source, there is no comprehensive ground water quality monitoring network similar to that for surface water. The economic costs of a large-scale data collection and analysis system would be high.

15. Although states presently have the major role in ground water protection programs, there is a wide variation among the states in their current ability to deal with such problems.

CHAPTER 14

WATER QUALITY

14.1 INTRODUCTION

Historically, rivers and streams have been used to meet a variety of human needs, including discharge of both human and industrial wastes. In addition, land disturbing activities, such as agriculture, urbanization, and mining, can create adverse impacts on water quality. Over the past 10 to 15 years a major national effort has been directed at reducing these impacts; for example, during 1976 alone it is estimated that industry spent 2.7 billion dollars on water pollution abatement (U.S., WRC, 1978a, Pt. IV, p. 109). These efforts are continuing to show positive results, with many streams, lakes, and estuaries showing substantial improvements. However, overall there are still many improvements needed to restore and maintain the nation's water resources (U.S., CEQ, 1979, p. 75).

As discussed in the previous chapter, water resources are a key ingredient to a healthy economy. Water must be adequate in both quantity and quality to meet needs for human consumption and other domestic purposes, to supply industry and agriculture, to maintain aquatic ecosystems (which may be economically important), and to provide recreational opportunities. Presently, overall water quality in the study area is relatively good (see e.g., U.S., EPA, 1978), especially when compared with the older industrialized and heavily populated areas of the Northeast and Great Lakes. However, a number of localized water quality problems currently exist in the southern region. As population and economic growth continues, pressures on water resources will increase; policies and management strategies need to ensure that increased water pollution does not threaten human health or become an unnecessary restriction to future growth.

Two major categories of pollution sources will be considered --point and nonpoint. Point sources are those industrial plants or municipal wastewater treatment facilities that discharge pollutants from a pipe or other conduit. Nonpoint sources are diffuse and include runoff from agricultural practices, mining, construction, and silvicultural areas; stream modification (e.g., channelization); and natural background releases arising from land not disturbed by man's activities (U.S., EPA, 1973, p. 1). The distinction between point and nonpoint source pollution is significant because their characteristics are different and they pose greatly different control problems (U.S., EPA, ORD, 1980). However, the categorization of point vs. nonpoint sources is not always clear. For example, urban storm water runoff is basically a nonpoint source, but it can be considered a point source if it is collected and discharged from a single source. When urban runoff is combined with sewage which leads to "combined sewage outflows" it is usually considered a point source.

This chapter will follow an organization similar to the other chapters in Part III of this report. The following section (14.2) discusses existing conditions and recent trends in water quality. This begins with a brief description of the regulatory system for controlling water pollution, followed by an overview of water quality across the region, including a short description of several specific water quality case histories. These cases were chosen to be illustrate and are not necessarily representative of all problem types or geographical areas in the Sunbelt. Section 14.3 addresses potential future problems and issues, including a description of key driving forces. The chapter concludes with a summary of key water quality issues for the future.

14.2 EXISTING CONDITIONS

14.2.1 The Regulatory System

The Federal Water Pollution Control Act (FWPCA) Amendments of 1972 and the Clean Water Act (CWA) of 1977 are the major pieces of federal legislation protecting water quality. They require standards, enforcement procedures, and research programs and provide for construction and other grants. Nationwide effluent standards are established by the Environmental Protection Agency (EPA) which approves state implementation programs to achieve water quality goals. According to the CWA, national water quality goals are to restore and maintain the chemical, physical, and biological integrity of the nation's waters by:

- Eliminating pollutant discharge into navigable waters by 1985;
- Achieving water quality protection and propagation of aquatic life and water recreation; and
- Prohibiting the discharge of toxic pollutants in toxic amounts.

A. Point Sources

Point sources are regulated through the National Pollutant Discharge Elimination System (NPDES). Permits for point discharges are issued by EPA or the state if it has an EPA approved implementation program. All of the 13 states in the study area have EPA approved permit programs.

Three categories of industrial discharges are established by the CWA:

- Conventional Pollutants: These are biological oxygen demand (BOD), suspended solids, fecal coliform, and pH. For these pollutants the CWA requires "best conventional pollutant control technology" (BCT) by July 1, 1984.
- Toxic Pollutants:[1] The CWA requires "best available technology economically achievable" (BAT) for 65 classes of toxic priority pollutants. Compliance deadlines for BAT are set for July 1, 1984. EPA is also to develop standards for the pretreatment of industrial wastes for industries that release the liquid wastes to publicly owned treatment works rather than a waterway. The purpose is to prevent chemical interference with sewage plant operations, to prevent the introduction of toxic pollutants that could pass through and be discharged from a sewage treatment plant, and to prevent the contamination of sewage sludge to an extent that would limit its beneficial use on land or other sound disposal practice (U.S., CEQ, 1980, p. 128).
- Nonconventional Pollutants: These are defined as all pollutants other than toxic or conventional ones, such as chemical oxygen demand, dissolved solids, and oil and grease. For these pollutants, dicharges must meet BAT standards within three years of their promulgation or by July 1, 1984, whichever is later, but in no case later than July 1, 1987 (U.S., EPA, 1978, p. 26). For these nonconventional pollutants, EPA may grant modifications of BAT if an industry shows that its discharge will not cause any significant adverse water quality effects (U.S., EPA, 1978, p. 26).

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[1] EPA has found that all primary industries regularly discharge one or more toxic priority pollutants. As of 1980, EPA had proposed BAT effluent limitations for toxic priority pollutants for nine primary industries (U.S., CEQ, 1980, p. 127).

For municipal discharges, the FWPCA required application of secondary treatment (or more stringent treatment to meet then existing water quality standards) by July 1, 1977, and "best practicable waste treatment technology" by 1983. The CWA authorized EPA to extend compliance deadlines on a discretionary basis up to July 1, 1983 (U.S., EPA, ORD, 1980). A major part of this pollution control effort was an EPA operated construction grants program to assist municipalities in financing the necessary works. Through 1980, Congress had appropriated 31.58 billion dollars for this program. As of the end of 1979, EPA had obligated 24.4 billion dollars (U.S., CEQ, 1980, p. 123). In Feburary 1980, EPA reported that 63 percent of major municipal treatment facilities were not yet in compliance with the original July 1, 1977 deadlines (U.S., CEQ, 1980, p. 131). Recently, it has been proposed that this program be substantially restricted.

B. Nonpoint Sources

No specific authority has been given to EPA to regulate nonpoint source pollution--both the 1972 and 1977 Acts left the development and implementation of specific control regulations up to state and local governments. However, EPA has been attempting to address nonpoint pollution primarily through the Water Quality Management Program created by Section 208 of the CWA. Section 208 establishes procedures under which states or regional agencies are required to prepare water quality management plans which include both point and nonpoint sources in surface and ground water. These procedures require the governor of each state to designate areas within the state that have "substantial water quality problems" and "a single representative organization including elected officials from local governments or their designees" as the 208 planning agency. The designated planning agency is required to operate "a continuing area-wide waste treatment management planning process." EPA must approve the plans prepared by the designated planning agency but the plans are not binding (Dolgin and Guilbert, 1974, p. 767).

Area-wide plans must address nonpoint source pollution problems that are related to: agriculture and silviculture; mining, including "new, current and abandoned surface and underground mine runoff" (FWPCA, 1972, §208[b][2][G]); construction; and "salt water intrusion into rivers, lakes and estuaries resulting from reduction of fresh water flow from any cause including irrigation, obstruction, ground water extraction and diversion" (FWPCA, 1972, §208[b][2][I]). Solid waste disposal problems that might affect surface or ground water quality must also be addressed in these nonpoint source control plans.

Several other federal and state programs also affect nonpoint sources. Section 208(j) of the 1977 Amendments authorizes the Department of Agriculture to provide grants for controlling agricultural pollution problems in areas or states with approved 208 plans. The 1977 Surface Mining Control and Reclamation Act has provisions for controlling nonpoint source pollution from mining. Also, the states, in cooperation with the Department of Agriculture Soil Conservation Service, have a number of soil erosion control programs. Part of the purpose of the 208 planning process was to assure coordination among these various programs (U.S., EPA, 1978, p. 26). However, the EPA 208 grants have recently been eliminated; to what extent these programs might be carried on by the states is unclear.

C. Other Legislation

Several other major pieces of federal legislation are also important for protecting water quality. The Safe Drinking Water Act of 1974 extended federal regulation of drinking water to all community supplies. EPA is responsible both for establishing drinking water quality standards and, as needed, for requiring application of specific water treatment technologies. Subtitle C of the Act, designed to prevent endangerment of underground drinking water sources, directs EPA to establish minimum requirements for state regulation of discharges from deep waste injection wells into ground water. The underground injection regulations allow for classification of aquifers into those which are or are not underground drinking water sources. They offer limited protection to those which are officially classified as drinking water sources and none to those which are not (U.S., CEQ, 1980).

The Safe Drinking Water Act allows EPA to designate an aquifer the sole or principal source of drinking water for an area. After such designation by the EPA administrator, "no commitment for Federal financial assistance...may be entered into for any project which the Administrator determines may contaminate such aquifers through a recharge zone so as to create a significant hazard to public health." As of December, 1981, eight aquifers had been designated "sole source," two of which are in the study area--the Edwards Aquifer in central Texas and the Biscayne Aquifer in southeast Florida (see Chapter 13).

Two other acts which influence water quality, the Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act, are discussed in Chapter 15.

14.2.2 Overview of Water Quality

This section provides an overview of existing water quality concerns in three categories: surface water, ground water, and drinking water. In addition to the broad overviews, several case examples are described to illustrate the nature of water quality problems or instances of successful pollution control efforts.

A. Surface Water

The following overview of surface water quality first considers impacts from point sources, followed by a discussion of nonpoint sources. As will be seen, surface water pollution is widespread across the region although the sources and types of pollution vary from place to place.

1. Point Sources

Table 14-1, based on EPA's 1977 National Water Quality Inventory Report to Congress, shows data on river basins "affected" by point source discharges, either industrial or municipal (U.S., CEQ, 1979). These figures are based on field data collated by the states in 1975 and 1976. Basins are classified as affected if the problems identified were not considered minor or insignificant, but this does not necessarily mean that water quality standards were violated. These data do have some limitations. They generally overstate the extent of some pollution since only a part of a basin may be affected. In contrast, other water problems may exist that are not reflected in the data; for example, in the case of toxic pollutants, monitoring data may not be adequate to identify a problem. However, these data are considered to present a good overview of the extent of pollution from these sources (U.S., CEQ, 1979).

Based on these data, surface water pollution from point sources is widespread across the U.S., including the study area. Only a few river basins in the U.S. are not affected by point source pollution in at least some part of the basin. In the Southeast, 74 percent of the basins are affected by industrial discharges, while 91 percent are affected by municipal effluents. In the Southcentral region, industrial and municipal effluents affect 70 and 100 percent of the basins, respectively. The most widespread pollution problems in both regions are bacteria, oxygen depletion, and nutrients. Heavy metal pollution affects 36 and 43 percent of the basins in the Southeast and Southcentral regions, respectively.

Figure 14-1 provides a slightly different perspective on surface water quality problems caused by point source discharges. The shaded areas indicate "significant" water quality problems as identified by federal and state/regional study teams as part of the Second National Water Assessment (U.S., WRC, 1978a, Pt. II, p. 20). Notice that the unshaded areas may not be problem free, but many problems were not considered major. The majority of significant problems are nutrients from municipal

TABLE 14-1: WATER POLLUTION IMPACTS FROM POINT SOURCES, 1977 (percent of basins affected)[a]

Pollutant	Geographical Region[b] Southeast	Southcentral	U.S. Total
Type of Point Source			
Industrial	74	70	72
Municipal	91	100	89
Pollution Type			
Thermal	11	3	15
Bacteria	77	73	78
Oxygen depletion	89	87	79
Nutrients	70	83	69
Suspended solids	26	30	35
Dissolved solids	9	30	17
pH	17	10	14
Oil and grease	6	13	16
Heavy metals	36	43	38
Nonmetal toxics	28	7	28

Source: U.S., EPA, 1978, p. 11.

[a] Basins where some (or all) stream segments have a problem that is not minor or insignificant, according to state officials. The total number of basins is: Southeast Region 47; Southcentral Region 30; U.S., 246.

[b] Note that the regional drainage basin groupings used here do not conform precisely to the federal regions. The Southeast Region includes the Southeast and Tennessee River basins, while the Southcentral Region includes the lower Mississippi River and western Gulf of Mexico basins.

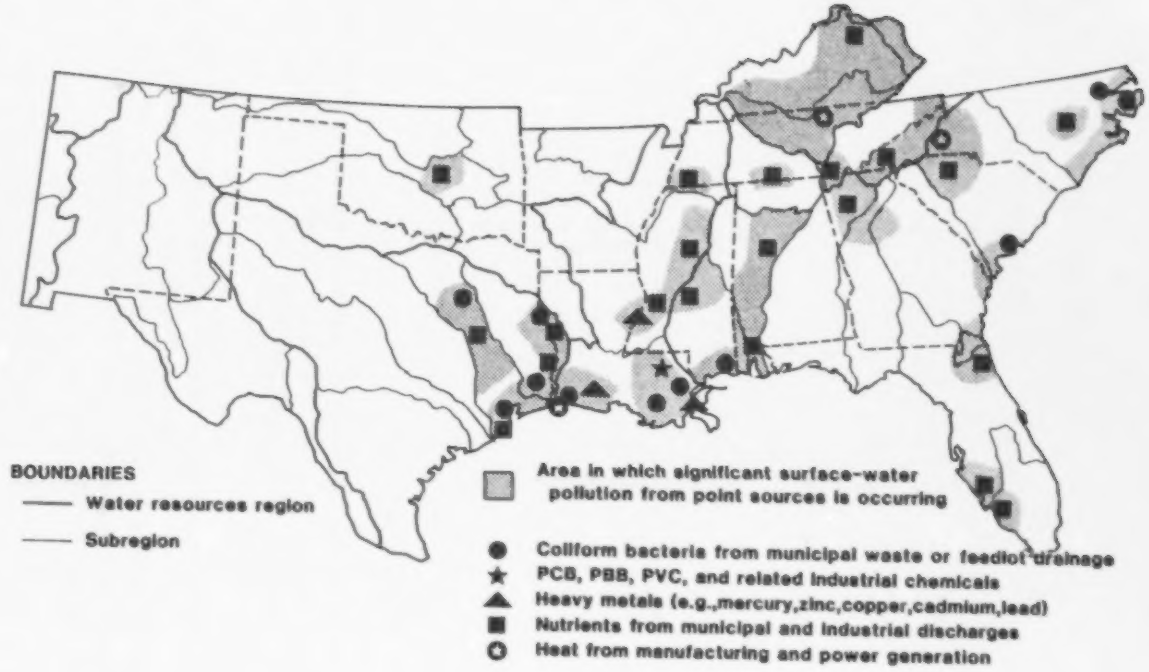
BOUNDARIES
Water resources region
Subregion
Area in which significant surface-water pollution from point sources is occurring
● Coliform bacteria from municipal waste or feedlot drainage
★ PCB, PBB, PVC, and related industrial chemicals
▲ Heavy metals (e.g.,mercury,zinc,copper,cadmium,lead)
■ Nutrients from municipal and industrial discharges
○ Heat from manufacturing and power generation

Figure 14-1: Surface Water Pollution Problems from Point Sources (municipal and industrial waste)

Source: U.S., WRC, 1978a, Pt. II, p. 20.

and industrial discharges and coliform bacteria from municipal waste or feedlot drainage. Five areas are indicated as having significant problems due to toxic materials such as heavy metals and polychlorinated biphenyls (PCBs)--four of which are in Louisiana.

2. Nonpoint Sources

Surface waters also are significantly affected by nonpoint sources of pollution which can be either natural or man-made. Nonpoint sources of water pollution are not as well understood or documented, and they are generally more difficult to control than point sources.

Based on the 1977 EPA National Water Quality Inventory Report to Congress, states reported that 87 percent of the basins across the country are affected by nonpoint source pollution (U.S., EPA, 1978, p. 15). Table 14-2 shows data for the study area and nationally on the percent of basins affected, both by the type of nonpoint source and by the type of pollutant. In the Southeast region, the most widespread nonpoint sources are urban runoff (57 percent) and agriculture (62 percent), with silviculture and individual disposal systems also affecting roughly one-third of the basins. The most widespread pollution problems in the Southeast are bacteria, oxygen depletion, and high levels of nutrients. In the Southcentral region, agriculture affects 87 percent of the basins, while urban runoff and mining (including oil and gas production) affect over one-half of the basins. In contrast to the Southeast, in the Southcentral region dissolved solids are the most widespread pollution problem, and toxics are judged to affect 47 percent of the basins compared to only 11 percent in the Southeast.

Figure 14-2 shows "significant" nonpoint source water quality problems.[1] In the study area, agriculture is a cause of significant problems in Mississippi, Kentucky, Louisiana, western Texas, and New Mexico. Excessive salinity is identified as a major water quality problem in Louisiana, western Texas and New Mexico. Water used for irrigation leaches salts from the soil, causing the salinity concentrations to increase in the return flows.

Along with sediments washed off the land surface (discussed further below), are herbicides, insecticides, and undesirable levels of fertilizers and other nutrients, all of which enter the streams. The National Residuals Discharge Inventory indicates that nationally about 33 percent of the oxygen-demanding loads, 66 percent of the phosphorus, and 75 percent of the nitrogen

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[1] Note that Figure 14-2 does not include pollution problems of bacteria or oxygen depletion, or sedimentation due to soil erosion.

TABLE 14-2: NONPOINT POLLUTION[a] (percent of basins affected)

	Geographical Region[b]		
Pollutant	Southeast	Southcentral	U.S. Total
Type of Nonpoint Source			
Urban runoff	57	50	52
Construction	2	0	9
Hydrologic modification	21	23	15
Silviculture	30	13	15
Mining	15	53	30
Agriculture	62	87	68
Solid Waste disposal	9	13	14
Individual disposal	40	40	43
Type of Pollution Problem			
Bacteria	66	53	61
Oxygen depletion	74	43	51
Nutrients	57	63	56
Suspended solids	34	37	54
Dissolved solids	4	70	30
pH	9	23	18
Oil and grease	4	3	9
Toxics	11	47	32
Pesticides	23	40	22

Source: U.S., EPA, 1978, pp. 15-16.

[a] Basins where some (or all) stream segments have a problem that is not minor or insignificant, according to state officials. The total number of basins is: Southeast Region 47; Southcentral Region 30; U.S., 246.

[b] Note that the regional drainage basin groupings used here do not conform precisely to the federal regions. The Southeast Region includes the Southeast and Tennessee River basins, while the Southcentral Region includes the lower Mississippi River and western Gulf of Mexico basins.

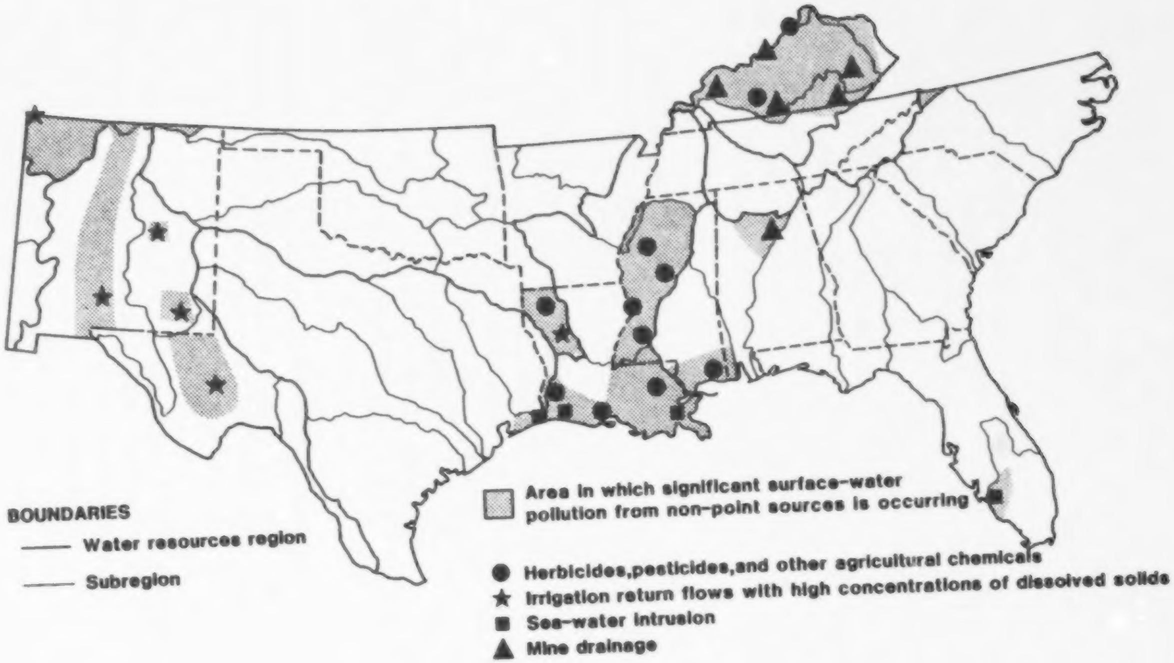
BOUNDARIES
Water resources region
Subregion
Area in which significant surface-water pollution from non-point sources is occurring
● Herbicides,pesticides,and other agricultural chemicals
★ Irrigation return flows with high concentrations of dissolved solids
■ Sea-water intrusion
▲ Mine drainage

Figure 14-2: Surface Water Pollution Problems From Nonpoint Sources (dispersed)

Source: U.S., WRC, 1978a, Pt. III, p. 21.

discharge into the streams in 1973 came from dispersed agricultural sources (U.S., WRC, 1978a, Pt. II, p. 23).

Kentucky and Alabama have identified acid mine drainage as a major problem. Where mining is or was prevalent, acid mine drainage pollutes both surface water and ground water supplies. Abandoned mines compound the problem since responsible parties are not available to deal with the problem.

Intrusion of saline water into fresh surface water is a major problem in several Sunbelt coastal areas. Impoundments and increased consumption of fresh surface water reduce the flows of fresh water to coastal estuaries. As the streamflow decreases, the saline water intrudes farther upstream. Not only can this upset sensitive and productive coastal ecosystems but also water users near the coast are faced with either using the degraded water or finding alternative and more costly sources. Intrusion of highly saline sea water into tidal estuaries has been identified as a problem at locations in Florida, Louisiana, and Texas (Figure 14-2).

Erosion of soils and the consequent sedimentation of streams, rivers, and lakes is a major water quality problem throughout the nation, including the study area (see Chapter 9). Figure 14-3 shows areas of significant erosion or sedimentation; problem areas include much of New Mexico, Oklahoma, Louisiana, the Mississippi River Valley, parts of Alabama and Georgia, and much of North and South Carolina. In addition to serving as a carrier of pollutants such as nutrients and pesticides, sedimentation causes economic and ecological damage by ruining fish spawning areas, clogging river channels, and filling lakes and reservoirs, thereby reducing storage capacity and shortening the life of the reservoir.

Other significant causes of water quality degradation from nonpoint sources are spills of oil, oil products, and other hazardous materials. Numerous hazardous material spills have been reported in both regions in recent years. For example, Figure 14-4 displays data for Region 4 on the number of transportation- and nontransportation-related oil spills reaching various waterways. From January 1976 through September 1977, transportation-related oil spills involved over 500 incidents and the release of more than 1.5 million gallons of oil. Between January 1975 and September 1977 there were over 400 nontransportation-related spill incidents involving about 0.5 million gallons (U.S., EPA, Reg. IV, 1978, pp. 18-19).

3. Specific Examples of Pollution

In addition to these overviews of water quality, another source of information is specific cases of either water quality

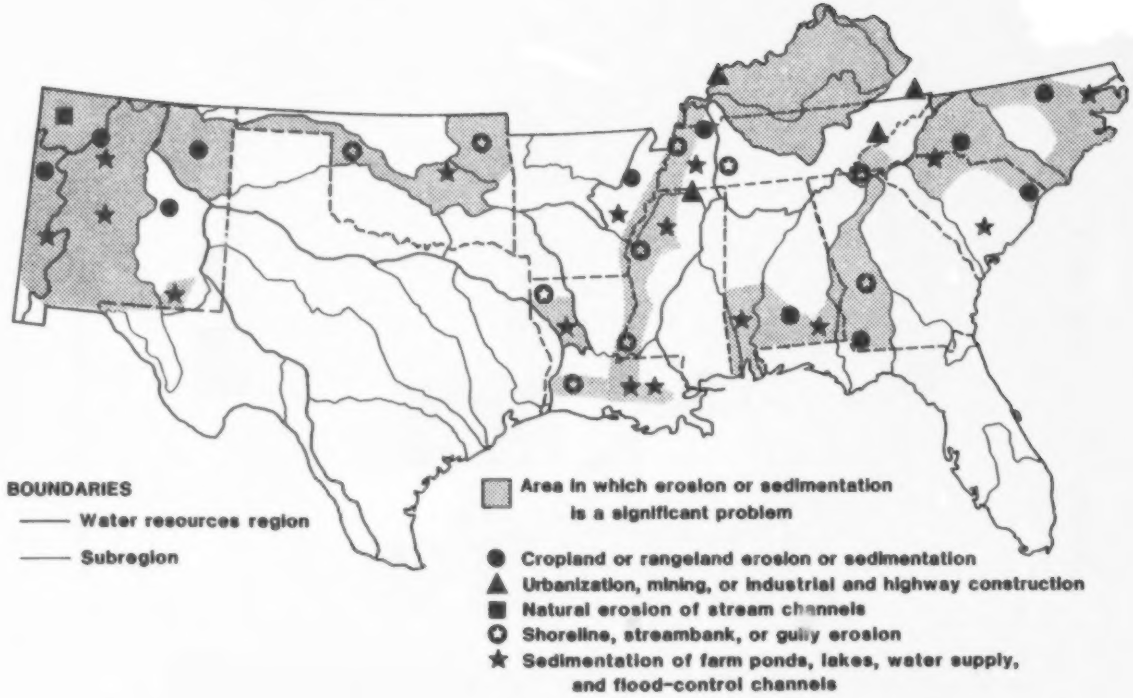
BOUNDARIES
Water resources region
Subregion
▨ Area in which erosion or sedimentation is a significant problem
● Cropland or rangeland erosion or sedimentation
▲ Urbanization, mining, or industrial and highway construction
■ Natural erosion of stream channels
○ Shoreline, streambank, or gully erosion
★ Sedimentation of farm ponds, lakes, water supply, and flood-control channels

Figure 14-3: Erosion and Sedimentation

Source: U.S., WRC, 1978a, Pt. II, p. 48.

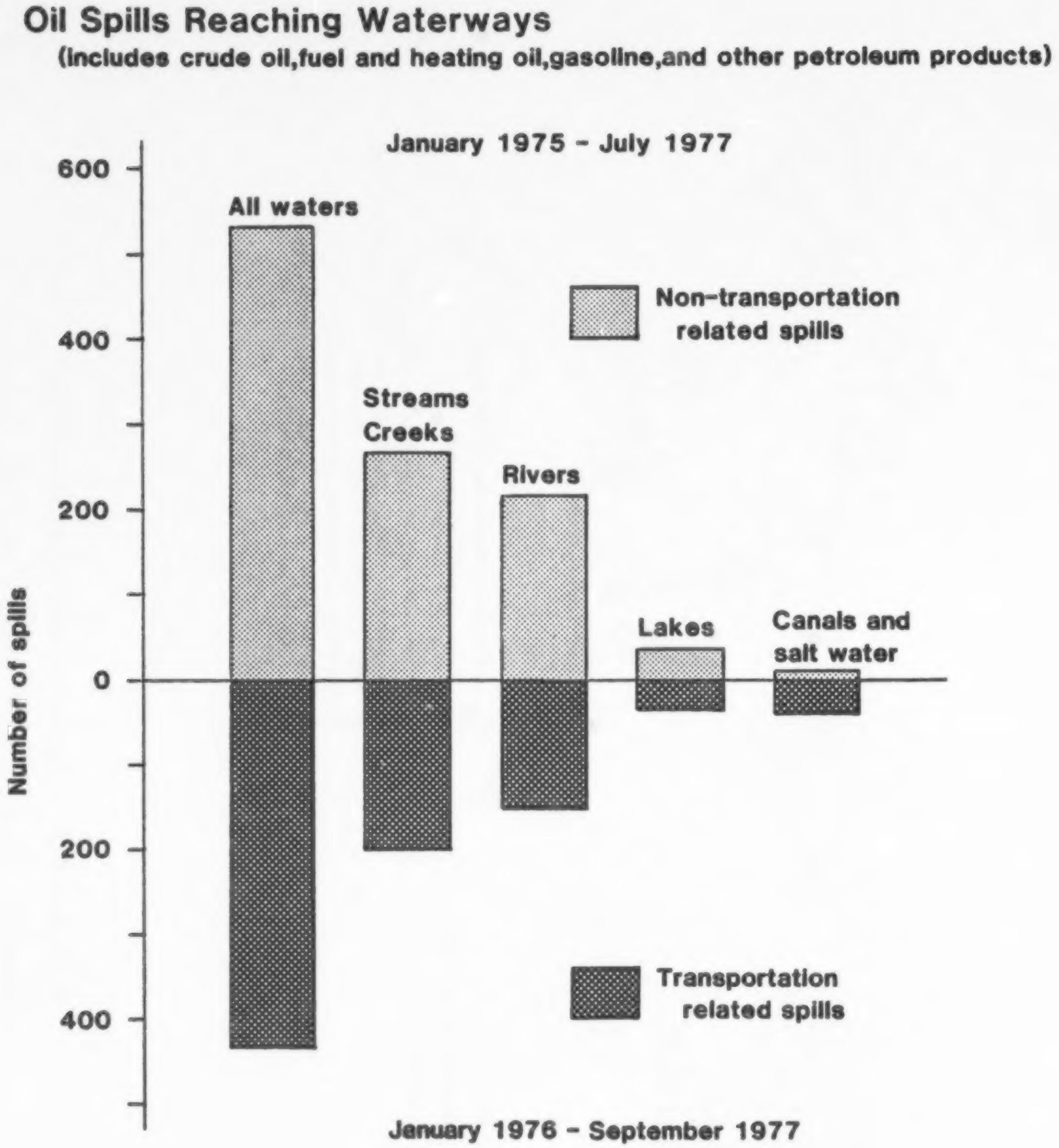

Figure 14-4: Oil Spill Data

Source: U.S., EPA, 1978, pg. 18.

problems or improved water quality conditions. The following pages discuss three specific cases of water quality concerns in the Sunbelt. These cases were chosen to be illustrative and are not necessarily representative of all problem types or geographic areas in the Sunbelt.

(a) Mercury Contamination in the North Fork Holston River (TVA, 1980, p. 12)

Mercury contamination of fish in the North Fork Holston River (running from southwest Virginia into northeast Tennessee) has been recognized as a chronic problem since 1970, when it was first discovered that the level of mercury in fish caught below Saltville, Virginia, exceeded the FDA limit. Subsequently, the river was closed to fishing, except for catch-and-release. The source of the mercury was a chloralkali plant which closed in 1972. Mercury from the old plant site and waste muck ponds continued to seep into the river, accumulating in the sediments and in aquatic plants and animals. Results of studies by the Tennessee Valley Authority (TVA) indicate that, even if the mercury seepage into the river were eliminated, natural processes within the river would continue to flush the contaminated sediments already deposited on the river bottom downstream. Independent investigations by TVA and Oak Ridge National Laboratory show that the mercury from the North Fork Holston River is being deposited and buried in sediments in Cherokee Reservoir, about 130 river miles downstream.

A task force chaired by the Virginia State Water Control Board and including representatives from EPA, the State of Tennessee, and TVA was formed in 1978 to develop solutions to these problems. Also, as directed by the State of Virginia, the company responsible prepared a three-phase comprehensive plan for managing the source of the pollution. While some corrective actions have been taken, as of 1980 the major mercury discharge had not been controlled, nor had the mercury levels in fish in the North Folk Holston River been significantly reduced.

(b) Water Pollution from the Dallas-Fort Worth Area (U.S., WRC, 1978b, pp. 42-43; see also Texas, Dept. of Water Resources, 1981, p. 13).

The Trinity River in the vicinity of the Dallas-Fort Worth metropolitan area suffers from both chemical and bacteriological pollution. Because of low streamflows, partially caused by upstream impoundments and the diversion of streamflows through municipal water systems, municipal effluents from both Dallas and Fort Worth often comprise the bulk of streamflow in the Trinity downstream of the metropolitan area. Although the river tends to purify itself as it flows downstream, some water quality problems are experienced as far downstream as Lake Livingston, a major water supply source for Houston.

The primary effects of effluent domination in the Trinity River are suppressed oxygen levels and high concentrations of BOD, ammonia, volatile suspended solids, phosphate, and fecal coliforms. At some points, sludges that contain high concentrations of carbon, nitrogen, and phosphorus accumulate on the river bottom. When the river rises rapidly, these sludges are suspended in the water and add heavy loads of pollutants, often resulting in extensive fish kills. Urban runoff also contributes significantly to the inflow of pollutants. Because of these water quality problems, much of the main stem of the Trinity River as well as portions of the West Fork and East Fork normally are unsuitable for recreation, domestic water supply, and industrial use without pretreatment. Game fish are generally unable to live in the Trinity River and tributaries below the metropolitan area because of the low dissolved oxygen levels, which occasionally reach zero.

All of the major wastewater treatment plant owners in the upper Trinity River Basin currently are upgrading their treatment facilities. This is expected to result in a significant improvement in the quality of the Trinity River.

(c) Pollution Control in the Neches Tidal Area
(U.S., CEQ, 1980, p. 109)

In 1973, the Texas Water Quality Board ranked the Neches Tidal Area (along the Gulf Goast of east Texas) as the second most polluted waterway in the state in terms of the amount of effort necessary to restore water quality. The Board also determined that two main industrial concentrations--chemical plants on Star Lake Canal and a complex of oil refineries, chemical plants, and a fertilizer manufacturer on Mobil Canal--could best meet water quality standards by tying into two central waste treatment plants being planned. Construction began in 1974, and both plants were on line in 1976. Between 1974 and 1976, EPA issued permits to 16 major industrial and 7 major municipal discharging facilities on or near the Neches. Between 1974 and 1978, EPA also issued permits to 51 minor industrial and 14 minor municipal dischargers. In 1976, the first tarpon in 30 years was caught in Sabine Lake on the Neches. Other aquatic life has been reappearing in the tidal areas of the Neches as well; shrimp are plentiful and commercial crabbers are working the river for profit.

B. Ground Water

1. Overview

Ground water supplies approximately 25 percent of the fresh water used in the U.S. About half of the U.S. population and about 95 percent of the rural population are dependent on ground water for drinking and other domestic purposes (U.S., CEQ, 1979, p. 105; and U.S., CEQ, 1980, p. 83). In 1970, in a seven-state southeastern region (Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Virginia) ground water supplied 44 percent of municipal, 89 percent of rural, 34 percent of industrial, and 56 percent of irrigation uses. In Florida, 91 percent of the population depended on ground water for drinking water supplies.

Ground water resources are threatened by overpumping (see Chapter 13) and by a variety of activities which create pollution. In many instances ground waters are hydrologically connected to surface waters; thus, surface water pollution may also impact ground waters. Other activities which can impact ground waters directly include disposal wells, industrial landfills and lagoons, municipal landfills, septic tanks or other on-site sewage disposal methods, mining, and petroleum production.

Table 14-3 provides a brief characterization of ground water quality for the water resource regions which are in the Sunbelt.[1] However, the extent of ground water quality problems and their potential for limiting future use of this resource are not well understood. No comprehensive national data exist on the level of ground water contaminants, the number of persons exposed, or the possible health effects. Most existing information comes from intensive local studies and anecdotal reports (U.S., CEQ, 1980, p. 91). Even in these case studies, the full range of water quality problems is unknown because most have focused on only a few of the several hundred compounds that might be involved. In some areas, re-analysis of samples revealed high concentrations of toxic substances not considered during the first analysis (U.S., CEQ, 1980, p. 92).

Figure 14-5 shows "significant" ground water pollution problems identified by state and regional study teams as part of the Second National Water Assessment (U.S., WRC, 1978a, Pt. II, p. 30). The western portion of the Sunbelt has widespread ground water quality problems, largely from natural sources. Four areas in Texas and Oklahoma are characterized as having saltwater contamination caused by well drilling. Across the region, four areas are identified as having ground water pollution caused by toxic industrial wastes, while two sites have been impacted by

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[1] See Section 13.2 for a map of these regions.

TABLE 14-3: SUMMARY OF GROUND WATER QUALITY IN REGIONS 4 AND 6

Region	Ground Water Quality
South Atlantic-Gulf	Ground water of good quality is generally available. Treatment for excessive iron, corrosiveness, and hardness is common. Salt water intrusion has occurred in some coastal areas. Local contamination has occurred through drainage wells and canals and through disposal of waste organic chemicals.
Ohio	Fresh ground water is usually found at depths of less than 500 feet. The deeper water in older formations generally is of poor quality and locally has migrated into heavily pumped aquifers. Industrial and municipal waste disposal has polluted the supply in numerous local areas.
Tennessee	Contamination of ground water occurs locally due to sink holes, septic tank and municipal waste disposal, and the shallow depth at which naturally mineralized water is found.
Lower Mississippi	Multiple fresh water aquifers of sand and gravel underlie about 90 percent of the region. Pollution from oil field and other industrial wastes occurs in the southern part of the region, and salt water encroachment has developed along parts of the Gulf Coast.
Arkansas-Red-White	Pollution has occurred locally from waste disposal, notably from mining and sewage ponds in the carbonate rocks of the Ozarks and Missouri. Water quality has been degraded from reuse of irrigation water along the Arkansas River. Deeper ground water is moderately to highly mineralized.
Texas-Gulf	Salt water intrusion has caused problems in the Texas City-Galveston-Orange area. Liquid waste disposal is being accomplished by deep injection to saline aquifers, and other wastes are being contained in landfills.
Rio Grande	In areas where the valley fill aquifers receive saline water from older rocks and the water evaporates, the ground water quality is poor--often a brine. Locally, carbonate rocks and sandstone in the central and southeastern parts of the region contain highly saline waters.

Source: Compiled by the U.S. Geological Survey, National Center, Reston, Virginia (U.S., CEQ, 1979, pp. 107-9).

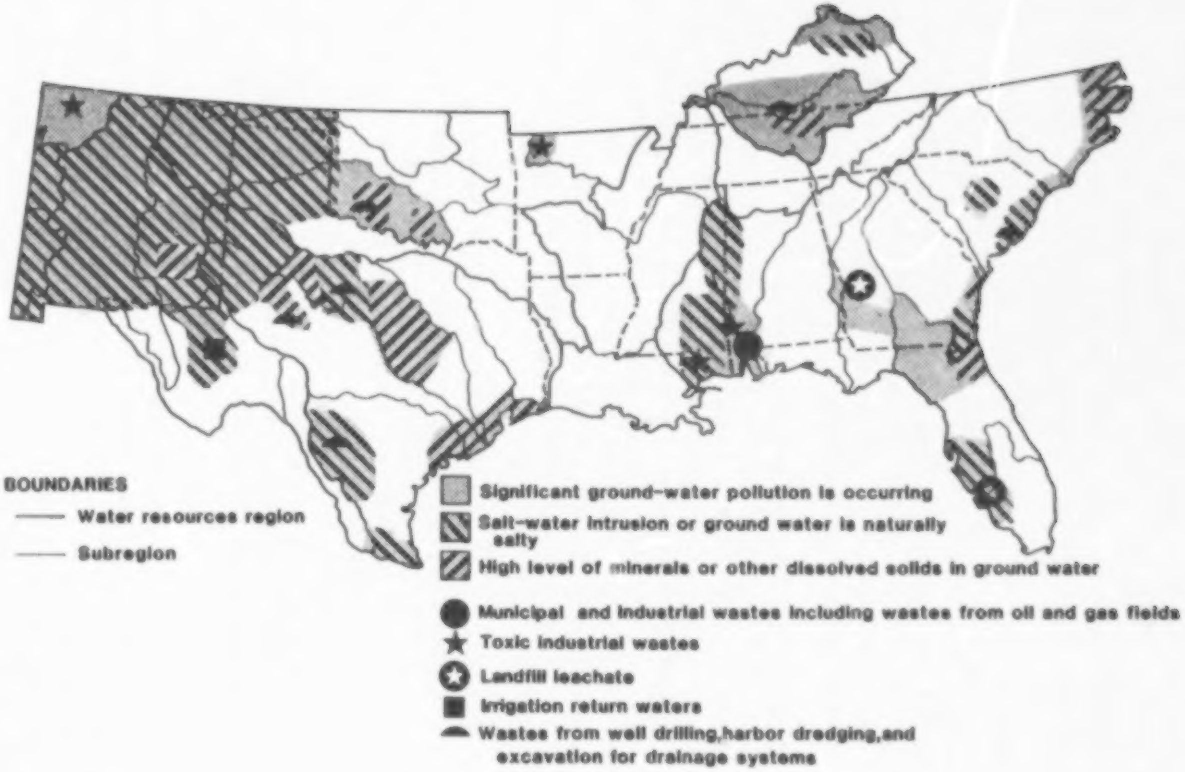
BOUNDARIES
Water resources region
Subregion
Significant ground-water pollution is occurring
Salt-water intrusion or ground water is naturally salty
High level of minerals or other dissolved solids in ground water
Municipal and industrial wastes including wastes from oil and gas fields
Toxic industrial wastes
Landfill leachate
Irrigation return waters
Wastes from well drilling,harbor dredging,and excavation for drainage systems

Figure 14-5: Ground Water Pollution Problems

Source: U.S., WRC, 1978a, Pt. II, p. 20.

landfill leachate. Several coastal areas are experiencing saltwater intrusion of ground waters due to overpumping of fresh water aquifers.

A 1977 report sponsored by EPA surveyed ground water quality in the southeastern U.S. covering seven states--Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Virginia (six of which are in our study area). Conclusions from this report include (Geraghty and Miller, 1977):

- Ground water can be developed throughout the region. The natural quality of ground water is good to excellent, except for the occurrence of saline water in some coastal aquifers. The most common natural water quality problems in fresh water aquifers are high hardness, high iron content, excessive fluoride concentrations, corrosiveness, and the presence of radionuclides.

- Surface impoundments, which are used for treating, handling, and storing liquid wastes and sludges, are leaking many millions of liters per year of potentially hazardous substances to ground water. The number of lagoons, pits, and basins is expected to increase sharply as industries change from direct surface water discharge to land treatment of wastes. In addition, industrial and municipal landfills covering large tracts of land are a source of ground water contamination throughout the region.

- The utilization of deep injection wells for underground storage of liquid industrial and municipal wastes is expected to increase considerably. However, drainage wells pose a more immediate threat to ground water quality, particularly in Florida where more than 6,500 such wells are known to exist and receive waters ranging from normal surplus waters to considerably polluted urban storm runoff and sewage waters, as well as a wide variety of other agricultural and industrial fluid wastes.

- Leaks and spills of hazardous and nonhazardous fluids on and below the land surface have occurred throughout the region. The most commonly spilled or leaked fluids are petroleum products that are in transferral, in transport, or in storage. As reported by well drillers, petroleum products in ground water supplies are the most common reason for well replacement.

- Ground water contamination related to agricultural activities occurs primarily from the use of excessive amounts of fertilizers on permeable soils or from the mixing of pesticides near wells. However, the heavy use of fertilizers and pesticides by home owners and pest control companies in urbanized areas probably has more impact on ground water quality than traditional agricultural activities.

- A significant source of ground water contamination is the discharge of partially treated sewage from septic tank systems. Approximately 13 million people in the region are served by on-site disposal, 76 percent of which are septic tanks or cesspools. As reported by well drillers in the region, bacterial contamination by septic tanks is the second most common reason for well replacement.

- The primary contaminant related to petroleum development activities has been the disposal of brines in seepage pits and disposal wells. Unplugged oil test wells have contaminated fresh water aquifers. An awareness of these problems probably will result in minimal future contamination despite accelerated exploration and development.

- The case histories reported are only a very small percentage of the instances of ground water contamination from all sources that exist in the region.

2. Case Examples

(a) Septic Tank Pollution (Geraghty and Miller, 1977, p. 246).

Pollution of a large spring in Gordon County, Georgia, was discovered when the City of Calhoun tried to use the spring to supplement its water supply. Total coliform density of three water samples taken over a 30-day period in 1971 ranged from 240 to 2,300 per 100 milliliter (ml). The fecal coliform density ranged from 15 to 430 per 100 ml. The source of the bacteria was a septic tank nearly half a mile away. The construction practice of removing too much soil when installing the septic tank above fractured bedrock was the presumed cause of the rapid movement of the septic tank effluent.

(b) Waste Disposal (U.S., EPA, Off. of Solid Waste, 1980, p. J-40).

The disposal of industrial wastes in an unlined sand pit in Crosby, Texas, resulted in the contamination of ground water, surface water, and the atmosphere. Disposal operations at the site began in the mid-1960's and in 1967 a waste disposal company purchased the pit from its previous owner. Various types of industrial wastes from the Houston area were disposed of in the pit. Leachate from the pit polluted the ground water causing contamination of 26 private wells in the area. Contamination included abnormally high concentrations of zinc, lead, manganese, iron, and cadmium. The San Jacinto River was also polluted due to the structural inadequacy of a sand dike.

(c) Hobbs, New Mexico Wastewater (U.S., EPA, Off. of Planning and Mgmt., 1980)

The wastewater treatment plant in Hobbs, New Mexico, was adding unsafe levels of nitrates to ground water in the Ogallala formation, which serves as the city's water supply. Since there are no waterways in the area to receive discharges, the plant used a trickling filter process followed by discharge into percolation ponds. As the treated effluent percolated into the ground it carried nitrates to the ground water. The New Mexico Environmental Improvement Agency was concerned about the high nitrate levels because they are a serious health threat, especially to infants. In response to the problem, the city decided to improve the wastewater treatment process it was using and sell part of the effluent. Oil producers buy the effluent and inject it into petroleum formations as part of their secondary oil recovery operations. The remaining effluent is pumped to a second facility for land application and denitrification. With EPA and state grants, Hobbs completed the land application facility in 1976. One quarter of the city's effluent is now sold for use in oil recovery, and the city soon expects to sign a contract with a second oil company that would nearly double the amount sold. Since the oil companies would be using ground water for their secondary recovery operations if the effluent were not available, Hobbs is helping to conserve water through the sale of its treated wastewater.

C. Drinking Water

1. Overview

The previous chapter discussed the provision of adequate domestic water supplies for an expanding population; an equally important consideration is the provision of high quality drinking water to ensure the health of current and future residents of the area. National concern over the quality of drinking water has heightened over the last 7 to 8 years and the public has become increasingly aware of the presence of toxic pollutants in drinking water. For example, the discovery of 66 organic chemicals in the New Orleans water supply in the early 1970's gave impetus to the passage of the 1974 Safe Drinking Water Act. Inorganic and microbiological water pollutants have been treated for some time. Improved analytical techniques have recently been used to identify organic compounds and trace metals not previously detected in drinking water supplies; these compounds are not normally removed by standard drinking water treatment methods. Several recently discovered pollutants are associated with cancer and other serious health problems. Sources of these pollutants include industrial and agricultural activities as well as the home use and disposal of chemicals (U.S., EPA, ORD, 1980, p. 441).

The contaminants of greatest health significance include:

(1) Heavy metals such as mercury, cadmium, and lead;

(2) Organics, including pesticides, PCBs, and trihalomethane precursors;

(3) Microorganisms, especially viruses; and

(4) Nutrients, which are exemplified by nitrates.

The greatest concern is probably their ability to cause chronic and/or acute physiological damage even in trace concentrations. Such undesirable constituents are noted for their persistence in the environment, especially in ground water, and for their ability to increase in concentration with subsequent use of the water, particularly surface waters. Current water quality standards (see Table 14-4) do not include limits on some of these contaminants and current surveillance and treatment procedures do not adequately address these pollutants.

Concern is increasing over chlorinated hydrocarbons, including trichloroethylene (TCE)--a widely used solvent and degreaser which has produced cancer in mice. Table 14-5 shows data for six states on the percentage of wells tested with detectable levels of nine chlorinated hydrocarbons (U.S., CEQ, 1980, p. 94).[1] TCE was the most frequently detected compound--across the five states where it was measured it was found in 8 percent of the wells. Although not shown in the table, across the full 39 cities covered in the study some compounds were detected at very high levels (e.g., TCE at 35,000 ppb). Also, tetrachloroethylene was found more frequently and at higher levels in finished water than raw water; the source of, or the mechanism which produces, this chemical is not known (U.S., CEQ, 1980, p. 92).

It is very difficult to deal with trace levels of toxic substances in drinking water. This is illustrated by the controversy surrounding EPA's proposed regulation as part of the Safe

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[1] The full study covered 39 cities in 18 states and measured both raw ground water and finished water.

TABLE 14-4: NATIONAL INTERIM PRIMARY DRINKING WATER STANDARDS

Constituent	Maximum Concentration (in mg/l unless specified)
Inorganic chemicals	0.05
Arsenic	0.05
Barium	1.00
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.00
Selenium	0.01
Silver	0.05
Fluoride	1.4 to 2.4
Organic chemicals turbidity	1 tu up to 5 tu
Coliform bacteria	1/100 ml (mean)
Endrin	0.002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4D	0.1
2,4,5 TP Silvex	0.01
Radionuclides	
Radium 226 and 228 (combined)	5 pCi/l
Gross alpha particle activity	15 pCi/l
Gross beta particle activity	4 mrem/year

Source: U.S., CEQ, 1979, p. 156.

mg/l = micrograms per liter
ru = turbity units
pCi/l = picocuries per liter
mrem = millirem

TABLE 14-5: ORGANIC COMPOUNDS FOUND IN GROUND WATER

Chemical	Percentage of Wells with Chemical Present					
	Alabama (80)[a]	Florida (329)[a]	Kentucky (22)[a]	North Carolina (44)[a]	South Carolina (4)[a]	Tennessee (50)[a]
Trichloroethylene	10	NM	0	18	0	14
Carbon tetrachloride	0	50	5	0	0	8
Tetrachloroethylene	4	20	0	5	0	2
1,1,1-Trichloroethane	10	15	0	2	0	26
1,2-Dichloroethane	3	15	0	7	25	8
1,1-Dichloroethane	8	36	0	14	0	26
Dichloroethylenes	10	38	0	45	50	26
Methylene chloride	0	1	NM	18	0	8
Vinyl chloride	1	16	0	34	0	6

NM = No measurements taken.

Source: U.S., CEQ, 1980, p. 94.

[a] Number of wells tested.

Drinking Water Act that would have required granular activated carbon (GAC) filters to protect against synthetic organic contaminants. The cost of installing GAC treatment in the 61 to 78 systems that would have come under the proposed regulation is estimated at between 10 and 20 dollars per month per household, with capital costs nationally estimated at between 615 million and 5 billion dollars (U.S., CEQ, 1979, p. 160).

Figure 14-6 shows areas and sources of drinking water problems as identified by federal and state/regional study teams as part of the Second National Water Assessment (U.S., WRC, 1978c, p. 67). Much of the western portion of the region is identified as having drinking water quality problems associated with salinity. Much of this problem is due to natural causes (see Section 14.2.2.B), but well drilling and irrigated agriculture have also contributed to the problem. Other problems are biological pollution in five areas, heavy metals in four areas, and chlorinated hydrocarbons in one area. The drinking water supplies in the Baton Rouge/New Orleans area, an area of heavy chemical and petrochemcial development, are impacted by several sources.

2. Case Examples

(a) Hardeman County, Tennessee (U.S., CEQ, 1979, p. 179).

In Hardeman County, Tennessee, 40 families near a rural landfill drank from wells polluted with such pesticides as endrin, dieldrin, aldrin, and heptachlor. The Velsicol Chemical Company had used a neighboring 300-acre site from 1964 to 1972 for shallow burial of 300,000 55 gallon drums of pesticide production residues. Residents have complained of a wide variety of ailments including liver and urinary tract problems, dizziness, nausea, and rashes. They filed a 2.5 billion dollar suit against Velsicol and in the meanwhile, had to hook into the water system of nearby Toone, Tennessee, at a cost of 200,000 dollars.

(b) Mississippi River Pollution (U.S., WRC, 1978a, Pt. 5, p. 38).

Between St. Francisville and Venice, Louisiana, some 60 industries discharge highly concentrated wastes into the Mississippi River. As a result, fish caught in the river below Baton Rouge are not marketable because of the off-flavor of their flesh. This reach, however, serves as a raw water supply for 40 utilities that furnish domestic water to a population of 1.5 million. Treated water supplies at two locations contain trace amounts of six organic chemicals capable of inducing abnormal tissue changes in animals. Treated domestic water supplies also contain three organic chemicals described as carcinogenic.

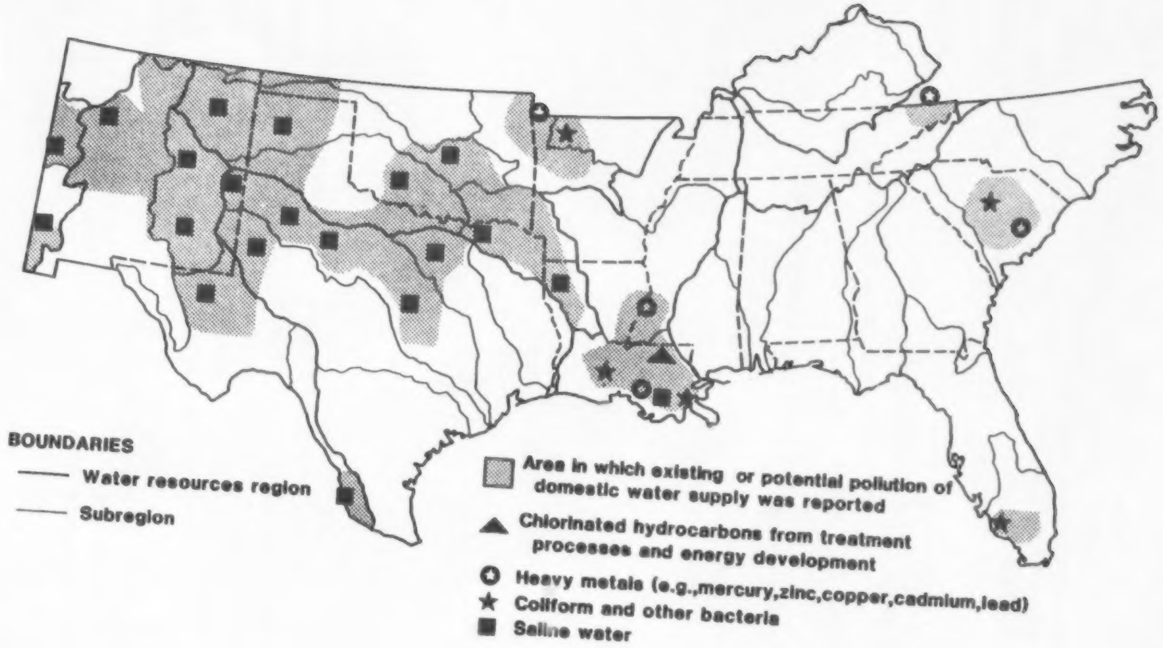
BOUNDARIES
Water resources region
Subregion
Area in which existing or potential pollution of domestic water supply was reported
Chlorinated hydrocarbons from treatment processes and energy development
Heavy metals (e.g.,mercury,zinc,copper,cadmium,lead)
Coliform and other bacteria
Saline water

Figure 14-6: Drinking Water Quality Problems (as identified by federal and state-regional study teams)

Source: U.S., WRC, 1978c, p. 67.

14.3 FUTURE TRENDS AND ISSUES

14.3.1 Key Driving Forces

As the Sunbelt continues to grow, the quality of the region's water resources will change. Whether the changes will be improvements or degradations depends on factors such as the degree and type of industrial growth, patterns of population growth, land use changes, the success of pollution control programs, and water use levels. Key driving forces with respect to water quality are:

- Industrial growth and change;
- Population growth; and
- Agricultural and silvicultural development.

Table 14-6 shows projections for those key driving forces and indicates pollutants of primary concern for each category.

As indicated in Table 14-6, population growth is projected to increase 31 percent in the region by 2010 (see Chapter 3). This will increase the potential for water quality degradation from domestic wastewater--both from centralized municipal sewage treatment plants and from individual systems (e.g., septic tanks). In addition, activities associated with population growth, such as urban development and highway construction, can increase nonpoint source runoff problems.

The industries listed in Table 14-6 are important because of a large projected growth (ranging from 41 to 352 percent) and because they have significant wastewater treatment requirements. However, in many cases only certain subclasses of these industries are a potential water quality concern; thus, growth in a broad category does not necessarily imply a proportional growth in water pollution potential. For example, the category of "Paper and Allied Products" includes many economic activities, but the only one of major water quality concern is pulp and paper production. Agriculture and silviculture production are important driving forces for water quality because the large land areas involved mean they can be significant nonpoint sources of pollution. In addition to the total land areas involved, crop patterns, management practices, and pesticide use are all important factors affecting impacts on water quality (see Chapter 9 for a discussion of trends in agriculture and silviculture).

TABLE 14-6: SIGNIFICANT POTENTIAL WATER POLLUTION SOURCES

Driving Forces	Earnings in Regions 4 and 6 (millions of 1972 dollars)			BOD	Solids[b]	Coliforms and Other Bacteria	Nutri-ents	Heavy[c] Metals	High/Low pH	Organics[d]	Pest-icides
	1978	2010	% change								
Population[a]	63.9 (1980)	83.9	+31	X	X	X	X				
Industry (SIC Code)											
Textile Mills (22)	4,485	9,241	+106	X	X				X	X	
Food Processing (20)	3,944	8,953	+127	X	X	X					
Paper and Allied Products (26)[e]	2,249	6,535	+191	X	X				X		
Chemicals and Allied Products (28)	4,368	15,902	+264	X	X			X	X	X	X
Petroleum Refining (29)	1,319	3,589	+172	X	X				X	X	
Rubber, and Misc. Plastics (30)	1,661	7,504	+352	X	X				X		
Leather and Products (31)	326	459	+41	X	X				X	X	
Primary Metals (33)	2,471	9,331	+278		X			X	X	X	
Fabricated Metals (34)	3,276	13,939	+325		X			X		X	
Transportation Equipment (37)	3,693	12,184	+230		X			X	X	X	
Machinery (35 and 36)	8,200	39,500	+382		X			X	X	X	
Agriculture (01 and 02)	6,460	10,130	+ 57	X	X	X	X				X
Lumber Products (24)[f]	2,220	5,750	+159		X		X				X

Sources: Nemerow, 1978; BEA data from chapters 4 and 9.

[a] Population is shown in millions of persons.

[b] Includes suspended and dissolved solids and increased salinity.

[c] Includes mercury, zinc, copper, cadmium, and lead, etc.

[d] Includes hydrocarbons and toxic organic chemicals.

[e] Especially important in this category is pulp and paper production.

[f] Excludes pulp and paper earnings.

14.3.2 Municipal and Industrial Point Sources

Point source pollution is associated with municipal sewage treatment facilities and heavy industries such as steel, chemicals, pulp and paper, and food processing. As the Sunbelt continues to industrialize and to grow in population, the potential for pollution from point sources will also increase. However, the actual level of pollution and its effects will depend on the degree of wastewater treatment applied, the particular industrial processes involved, and the siting of the discharge points.

Most of the major pollution control efforts under the impetus of the CWA have focused on point sources--initially on "conventional" pollutants (BOD, suspended solids, etc.) and more recently on toxic substances. The basic regulatory structure for requiring stringent controls is in place under the NPDES system. However, there are still many difficult technical and economic problems associated with implementing these pollution control programs; for example, of the 5,623 municipal sewage treatment projects begun since 1972, only 1,552 were in operation as of December 1979 (U.S., CEQ, 1980, p. 100). The Council on Environmental Quality's analysis of national water quality trends between 1975 and 1979 for six water quality indicators showed little or no change.[1] That is, while many heavily polluted basins have substantially improved (e.g., as in the case of the Neches Tidal Basin described earlier) and others have continued to deteriorate, a high percentage of basins showed no significant change. This underscores the fact that it will be several more years before the full effect of water pollution regulatory efforts is evident (U.S., CEQ, 1980, p. 100).

Long-term water pollution trends from point sources in the Sunbelt will depend on a complex set of factors. Population and industrial growth will lead to greater amounts of domestic sewage and industrial wastewater which will require treatment and disposal. Mitigating these threats, implementation of point source control technologies will reduce the quantities of pollution discharged per unit of population and per unit of industrial production. The effectiveness of controls will vary from pollutant to pollutant and from industry to industry. Also, shifting water use patterns and alteration of hydrology (discussed in Chapter 13) can affect the quantities of water in receiving streams, thus affecting pollution concentration levels. It is uncertain how these factors will interact along with nonpoint sources of pollution to affect overall water quality in the Sunbelt. An important need in this regard is research which assesses such trends on a river basin, state, or regional basis.

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[1] Data was from the U.S. Geological Survey's National Stream Quality Accounting Network.

However, EPA's Environmental Outlook 1980 report analyzed water pollution trends from a variety of sources, including municipal and industrial point sources (U.S., EPA, ORD, 1980, ch. 6). This study, based largely on the Strategic Environmental Assessment System (SEAS), analyzed several different pollutants on a national and federal regional basis. For each pollutant, three categories were considered: (1) gross generation--the amount of a pollutant which exists in wastewaters of a plant before being subject to treatment; (2) net discharges--the amount of a pollutant that would be discharged in waste streams even after full treatment to meet the standards required by law; and (3) intermediate discharges--calculated as the level of a pollutant discharged if removal efficiencies were to remain at their 1975 level.[1] Generally, the analysis showed that because regions 4 and 6 are projected to experience large economic and population growth, gross generation of pollutants will increase substantially. However, if stringent levels of pollution control are assumed, net discharges to waterways from these point sources show declines for most pollutants. This is especially the case for toxic pollutants which are subject to more stringent standards than "conventional" pollutants (BOD, suspended solids, etc.). If only intermediate discharge levels were met, then pollutant loadings would increase in every case, generally by at least a factor of 2. In short, this analysis showed the importance of complying with existing or proposed effluent guidelines if point source water pollution is to be improved or maintained in the Sunbelt.

Additional findings from Environmental Outlook 1980 relevant to federal regions 4 and 6 are summarized below. The purpose of this discussion is to briefly examine the major factors which will affect pollution trends and the uncertainties involved in such projections. Some of the important assumptions, data deficiencies, and uncertainies are (U.S., EPA, ORD, 1980, ch. 6):

- Overall, assumptions about compliance should be considered optimistic. Treatment levels are based on compliance deadlines specified in the 1972 FWPCA and do not incorporate changes in the 1977 CWA, although imposition of BAT standards on industrial sources is assumed to lag two years behind schedule and thus they will not be met until 1985. Also SEAS projections based on BAT for industrial sources should be considered optimistic since BCT will probably be less stringent.

- On the other hand, application of more stringent standards based on receiving water quality in some areas could cause SEAS projections on discharges to be overstated.

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[1] The calculation of intermediate discharges was not included for some pollutants, including phosphorus, chemical oxygen demand (COD), and toxics.

- SEAS discharge estimates are likely to be understated because not all industrial categories are covered and comparisons with other data sources indicate that some discharge coefficients may be underestimated.

- Regional differences in compliance schedules, water quality based standards, and levels of treatment which may exist are not accounted for.

- Although the importance of toxic pollutants is recognized, there is a considerable lack of systematic data on industrial discharges, especially in the case of toxic organic chemicals. Consequently, SEAS toxic pollution estimates are fragmentary and cover only a small fraction of the 65 classes of priority toxic pollutants recognized by EPA.

Despite these difficulties, analysis of these projections is useful in helping to understand some of the complex interrelationships between industrial/population growth and the potential for increased water pollution.

Table 14-7 summarizes the trends for five pollutants in terms of both gross generation and net discharges. Key points concerning these findings are (U.S., EPA, ORD, 1980, ch. 6):

- BOD: Despite dramatic increases in gross generation due largely to growth in population and pulp and paper production, net discharges are projected to decrease over 30 percent in each region. Municipal treatment facilities are forecast to remain the major point discharges of BOD throughout the 1975 to 2000 time period. The pulp and paper industry is currently, and is projected to remain, the largest industrial source of BOD but if full compliance is achieved by the industry, net discharges would decline by 85 percent. This would particularly benefit Region 4 since the SEAS projections show it accounting for 25 percent of pulp and paper production in 2000, second only to Region 5 (26 percent) (U.S., ORD, EPA, 1980, ch. 6).

- Suspended Solids: Gross generation of suspended solids is projected to increase sharply through 2000, but full compliance with BAT standards would cause a substantial downward trend in net discharges. The largest generation sources of suspended solids are municipalities, pulp and paper, aluminum, steel, and coal preparation. Assuming full compliance with effluent guidelines, in 2000 municipal sources would account for 75 percent of net discharges nationally.

TABLE 14-7: POINT SOURCE POLLUTION TRENDS
(percent change between 1975 and 2000)

	Region 4		Region 6	
Pollutant	Gross Generation	Net Discharge	Gross Generation	Net Discharge
BOD	+ 97	- 35	+ 93	- 31
Suspended Solids	+160	- 65	+212	- 89
Dissolved Solids	+163	+140	+183	+130
Nitrogen	+ 60	+ 17	+ 72	+ 43
Phosphorus	+ 42	- 6	+ 75	+ 36

Source: U.S., EPA, ORD, 1980, ch. 6. Based on the "high growth scenario."

- Dissolved Solids:[1] Although water quality criteria for dissolved solids exist, there are no national effluent guidelines and control of dissolved solids typically occurs only coincidentally in the control of other pollutants. As shown in Table 14-7, both gross generations and net discharges are projected to show increases. The organic chemicals industry is a major point source of dissolved solids in regions 4 and 6.

- Nitrogen:[2] Large increases in gross generation of nitrogen compounds are projected in both regions, primarily due to population growth. Higher nitrogen generation levels are also expected to result from increases in output of nitrate fertilizers, meat products, organic chemicals, and steel industries in Region 4. Net discharges increase primarily because of the release of nitrogen from municipal treatment facilities and the organic chemicals industry.

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[1] Municipal sources were not included in this analysis since estimates for dissolved solids levels in municipal sewage were not available.

[2] There are not general effluent standards for nitrogen compounds but controls for other pollutants coincidentally remove some nitrogen. In addition, in the case of water quality-limited receiving waters, some facilities have nitrogen effluent limitations imposed.

- Phosphorus:[1] Municipal sewage is by far the most significant point source of phosphorus and, thus, overall trends primarily follow trends in this source. Despite a projected 40 percent increase in phosphorus generation in Region 4, net discharges are expected to decline slightly because of effective controls in the inorganic chemicals and meat products processing industries. However, increases in net discharges from municipal sewage treatment plants are expected to partially offset industrial improvements. The increase in both generation and net discharges in Region 6 are due primarily to population growth, as sewage effluent accounts for over 80 percent of the gross generation and 95 percent of the net point discharges in this region.

The Environmental Outlook 1980 report also analyzed trends for selected toxic chemicals, but generally on a national basis rather than on a detailed regional basis. Findings for three of these toxic compounds are presented below in order to illustrate some of the trends and uncertainties involved.

- Cadmium: Net discharges were projected to decrease by 72 percent nationally due to an assumption of zero discharge after 1985 (BAT) by the electroplating industry, a major source at present. Only the organic chemical industry and nonferrous metals industries were projected by SEAS to release significant quantities of cadmium after 1985. Region 6 showed the greatest growth in gross generation, while regions 2 and 4 would account for the greatest portions of net discharges.

- Mercury: Gross generation of mercury is expected to decline nationally from over 350 tons in 1975 to 130 tons in 2000, and net discharges are estimated to remain at below 5 tons per year. Over 99 percent of mercury discharges came from the inorganic chemicals industry in 1975 and the projections show this industry would discharge less than one ton per year by 2000. Regions 4 and 6 are projected to remain the major generators of mercury wastes, especially Region 6 which is projected to account for 38 percent of the national total. However, for all regions the projections of net discharges by 2000 are considered to be "insignificant" (U.S., EPA, ORD, 1980, p. 319).

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[1] Phosphorus is discharged in two forms: elemental phosphorus which is particularly toxic to animal and plant life and subject to bioaccumulation; and phosphates, which is one of the major nutrients required by plants.

- Phenol and Phenolic Compounds: These toxic pollutants are present in industrial wastewaters as both dissolved solids and as oil and grease. In Region 6, net discharges of phenol are projected to decline by 95 percent due to considerable improvement in controls on the organic chemicals industry (in the form of oil and grease) and the petroleum refining industry. In contrast, net discharges in Region 4 are projected to decline by only 27 percent by 2000. This is due to significant improvement in controls by the steel, organic chemicals, plastics, and petroleum refining industries being offset somewhat by increases in net discharges by the aluminum and textile industries.

In summary, many factors will interact to affect future point source pollution levels in the Sunbelt. In contrast to nonpoint sources, the basic regulatory structure is in place through the NPDES program to control pollution from point sources. Past efforts under this program resulted in dramatic improvements in discharge levels and receiving water quality in many specific areas. If current standards are met, improvements can be expected to continue. However, in spite of these controls continued degradation can be anticipated in some instances due to expanding population and industry. For example, discharges of dissolved solids and nitrogen can be expected to increase. Of course, the water quality changes and resulting impacts will be site-specific. Finally, much more work is required in the area of toxics. Water quality management agencies have a good understanding of conventional pollutants from point sources, but not of toxics. Water quality standards and monitoring networks do not address many toxics in most states, and EPA only recently published ambient criteria for 65 priority toxic pollutants (U.S., EPA, Off. of Water Program Operations, 1981, p. 7).

14.3.3 Nonpoint Sources

As described earlier, nonpoint source pollution is currently widespread, nationally and in the Sunbelt. The most significant sources are runoff from agricultural, silvicultural, and urban areas, and discharges from individual sewage systems (e.g., septic tanks). In contrast to point sources, very little progress has been made during the 70's in controlling these sources of pollution. If water quality goals are to be met, controls on nonpoint sources must be improved. Trends and issues for two of the most important categories of nonpoint pollution--urban runoff and agricultural runoff--are discussed below. EPA's highest national priority nonpoint source problems are for these two sources (U.S., EPA, Off. of Water Program Operations, 1981, p. 6).

A. Urban Runoff

Urban rainfall runoff is currently cited as a significant contributor to water quality degradation in heavily populated areas (U.S., EPA, 1978, p. 16), and as the Sunbelt grows, its relative contribution to water pollution will increase. Almost every type of pollution is found in urban runoff, with the most severe effects coming from suspended solids and heavy metals. Bacteria, BOD, COD, nutrients, and oil and grease also are associated with urban runoff. These pollutants come from such sources as air pollutants that settle in the streets, organic debris, animal wastes, discarded litter, oil, and fertilizers and other lawn care chemicals.

Discharges of urban runoff can be of three types:

- Storm sewers;
- Combined sewers (i.e., sewers in which rainwater is combined with domestic sewage); and
- Unsewered runoff.

Overflows of combined sewers can represent a significant source of pollution in addition to that associated with rainfall runoff. Control of urban runoff does not come under any specific federal effluent guidelines, but discharges from storm sewers and combined sewer overflows are subject to NPDES permits. That is, once urban runoff enters the sewer system, it is supposed to meet applicable NPDES requirements (U.S., EPA, ORD, 1980, p. 346). Therefore, technically speaking, combined sewers and storm sewers are considered to be point sources, but they are often discussed as a nonpoint source.

Attempts to quantify current pollutant loadings or to project future trends in urban runoff are subject to considerable uncertainty. In the 1976 National Residuals Discharge Inventory, it was estimated that urban runoff contributes 1.7 million tons per year (tpy) of BOD and 30 million tpy of suspended solids. However, these estimates may err by an order of magnitude (Luken, Basta, and Pechan, 1976). Table 14-8 shows one estimate of the

TABLE 14-8: ESTIMATED MIX OF U.S. URBAN RUNOFF POLLUTION (thousands of tons)

Pollutant	1975
BOD	370
COD	3,400
Suspended Solids	6,300
Dissolved Solids	4,000
Phosphorus	5
Nitrogen	58
Oil and Grease	86

Source: U.S., EPA, ORD, 1980, p. 350.

typical composition of pollutants in urban runoff on a national basis. On a regional basis it is estimated that urban runoff discharges in regions 4 and 6 are equal to 16 percent and 8 percent respectively of the national total (U.S., EPA, ORD, 1980, p. 351).

Various nonstructural and structural control measures can reduce urban runoff pollution. Nonstructural measures (or Best Management Practices [BMP's]) focus on prevention and include measures such as land use planning, use of natural drainage features, erosion controls, street repair and sweeping, collection system maintenance, control of litter, use of detention ponds, and on-site storage for runoff. Structural alternatives include conventional wastewater treatment practices, including primary and secondary treatment devices and high- and low-density area reservoirs (Metcalf and Eddy, 1977, pp. 12-13).

Because sewered urban runoff is usually concentrated when the first appreciable amount of rainfall occurs (that is, the "first flush" effect), and is released from a set of discharge points, a significant amount of pollution control can, in theory, be achieved using structural alternatives during the first flush. Nevertheless, nonstructural alternatives generally are preferred, both for sewered and unsewered urban runoff, because of lower costs, faster results, and better water quality protection. However, the primary difficulties in using them are that benefits are nearly impossible to quantify and they must be implemented on a large scale basis to be effective (Metcalf and Eddy, 1977, pp. 12-13).

Because regions 4 and 6 are projected to have the largest population increases over the next 30 years, they are expected to have the largest increase in urban runoff pollution. These projections are uncertain and actual pollution levels will depend on specific land use patterns and control measures. If it is assumed that increases in urban runoff loadings are directly proportional to urban population increases, then improved structural or nonstructural controls would be required in order to maintain 1975 levels (U.S., EPA, ORD, 1980, p. 353).

In an attempt to improve the control of urban runoff, EPA instituted the Nationwide Urban Runoff Program. Twenty-eight urban areas were selected in which data will be collected to assess urban nonpoint source problems and evaluate the effects of these sources on receiving water quality. The program will also evaluate BMPs which could be used to control the pollution from urban runoff. Most of these prototype projects will be completed between FY 81 and FY 83 (U.S., CEQ, 1980, p. 135; U.S., EPA, Off. of Water Program Operations, 1981, p. 9).

B. Agricultural Runoff

In rural areas, agriculture--irrigated and nonirrigated crop production and animal production--is the main nonpoint source of water pollution. Pollutants of concern include sediments, nutrients, pesticides, dissolved solids (salinity), and bacteria. As agricultural production grows and practices change, they can have a significant effect on water quality (see Chapter 9). In the southern region, for example, about 200 million pounds of pesticides and 6 million tons of fertilizer are applied annually at the present time. Agricultural activities have been estimated to currently affect 62 percent of the basins in Region 4 and 87 percent of the basins in Region 6 (see Section 14.2.2.A).

Nonpoint source water pollution from agricultural activities can be controlled most effectively at the source through the use of BMPs. For crop production, in particular, proper land use and agricultural management practices are the key to protecting water quality. Erosion, and hence sediment loads, can be reduced by use of terraces, diversions, strip cropping, contouring, grassed waterways, no-till farming and/or crop rotations. Nutrient releases can be reduced by improved planning of fertilizer applications. For example, alternating production of nitrogen-fixing crops with crops requiring heavy fertilization can reduce the long-term average quantity of nitrogen that must be applied to soil. For pesticides, as with nutrients, BMPs must include consideration of timing, type, amount, and method of application. These control measures can be used in conjunction with integrated pest management, which attempts to minimize the use of chemical pesticides through crop rotation, mechanical measures to remove food for pests, biological controls (fungus-coated seeds or predator insects), insect sterilization, use of natural toxins and insect attractants, and development of disease-resistant crops (Thronson, 1978, p. 0-2).

The particular BMPs to be used depend on site-specific conditions and their effects on nonpoint source pollution are highly variable from crop to crop and from locality to locality. Thus, it is difficult to generalize about reductions in sediment and other pollutant loads to be expected from the adoption of BMPs (U.S., EPA, ORD, 1980, p. 358).

Agricultural water pollution trends have been analyzed in Environmental Outlook 1980. They are summarized below for the Sunbelt Region. Limitations of these projections are as follows:[1]

- The analysis was limited to only eight major crops (corn, cotton, soybeans, wheat, tobacco, potatoes, citrus fruit, and apples) which account for only about one-half of all crop acreage, but about 80 percent of crop acreage receiving pesticides and fertilizers;

- Continuation of current trends in pesticide and fertilizer use is assumed. Although it is expected that BMPs will become more widely used (especially since the USDA is to provide 50 percent funding for practices to improve water quality), it is difficult to quantify the effects of such practices;

- Estimates of sediment and nutrient releases appear to be too low by at least a factor of 8 to 14 due to incomplete coverage of all crops and low estimates on discharge coefficients.

Although these and other limitations make absolute discharge levels uncertain, the trends and regional distribution revealed in the projections improve our understanding of where agricultural runoff may be of greater concern in the future and some of the factors contributing to these changes.

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[1] The projection methodology used the following factors: crop production forecasts projected within the economic module of SEAS; crop yield forecasts from USDA; annual erosion estimates per acre by crop and soil type calculated using estimated rainfall; soil erodibility and topography; crop management factors and conservation practices using the "universal soil loss equation"; sediment delivery ratios based on the size of the drainage area; and pesticide and fertilizer application rates by crop based on projected trends for the USDA (U.S., EPA, ORD, 1980, p. 359).

Table 14-9 summarizes some of the findings from the Environmental Outlook 1980 report for regions 4 and 6.

- Soil Loss: Soil loss, and hence sediment, would increase 19 and 14 percent in regions 4 and 6, respectively. These projections do not take into account potential improvements through the use of BMPs; however, it is estimated that BMPs can reduce soil loss per acre by 30 to 50 percent (USDA, SCS, 1978). Hence, if such measures were applied region-wide, net discharges of sediment could actually be reduced by 2000.

- Nutrients: Discharges of nutrients (nitrogen, phosphorus, and potassium) are projected to increase substantially in both regions--about 50 percent for nitrogen and 100 percent for phosphorus and potassium. On an absolute basis, Region 4 contributes considerably more of these nutrients than Region 6. Across regions 4 and 6, increased soybean production is projected to account for a substantial share of the increased nutrient loadings.

TABLE 14-9: PROJECTIONS OF AGRICULTURAL POLLUTANTS

	Region 4		Region 6	
	1975	2000	1975	2000
Pollutant	Quantity (tons)	Percent Change	Quantity (tons)	Percent Change
Soil Loss[a]	900	+ 19	590	+ 14
Nitrogen	840	+ 53	560	+ 48
Phosphorus	480	+107	280	+ 97
Potassium	240	+100	120	+ 92
Herbicides	44	+ 81	23	+ 79
Insecticides	25	+ 24	33	- 3
Fungicides	1.1	+300	0.2	+800
Miscellaneous Pesticides	23.5	- 28	6.5	+ 3

Source: U.S., EPA, ORD, 1980, pp. 364-85.

[a] Suspended solids, dissolved solids, and BOD discharges are assumed to be proportional to soil loss.

- Pesticides: Gross discharges of pesticides (herbicides, insecticides, fungicides, and miscellaneous) are much smaller than other pollutants but are potentially significant because of their toxicity. Discharges of fungicides are projected to show the greatest relative increase, largely due to increased use per acre on potatoes and soybeans and higher soybean acreage. However, absolute levels of fungicide discharges are still relatively small, and the environmental concerns associated with a large increase are unknown. Miscellaneous pesticide discharges are projected to decrease dramatically in Region 4 because of decreased use per acre on tobacco, but this region would still account for 64 percent of the national total.

In sum, water pollution from agricultural activities is widespread and considerable uncertainty exists about the effectiveness of controls. Also, most control programs are voluntary and because of their expense, there are implementation barriers (see Chapter 9). Approximately 30 prototype agricultural projects and 13 Rural Clean Water Program projects, supported by EPA and USDA, will be completed between FY 81 and FY 83. These prototype projects are selected to provide answers to key questions involving cause/effect relationships, cost-effectiveness of controls, and fiscal/financial arrangements. The overall goal is to build a national nonpoint source control data base (U.S., EPA, Off. of Water Program Operations, 1981, p. 9).

14.3.4 Ground Water Protection

Protection of ground water quality is different from surface water protection in several ways. First, the public has only recently begun to realize the extent to which ground water has already been degraded and the continuing threats that exist. This is partly due to the fact that ground water is out of sight and, thus, pollution of this resource is not as immediately obvious. Thus, regulatory and research programs to protect ground water have lagged several years behind those for surface water and to a great extent are still largely undeveloped.

Second, data on ground water contamination are sparse, and most information comes from intensive local studies and anecdotal reports (see Section 14.2.1). There is no nationwide ground water quality monitoring network similar to that for surface water. Two factors contribute to the difficulty of assessing ground water quality problems: (1) sampling problems--ground water quality measured from one point in an aquifer may not be representative of the water even a few hundred feet away; and (2) system definition problems--monitoring and projecting ground water quality changes for an aquifer require an understanding of recharge and discharge areas, rates and direction for water movement, geochemistry of the aquifer, etc., which is a lengthy and difficult process.

Third, in contrast to surface waters, future projections of pollution discharges to ground water are essentially nonexistent. This is explained not only by the very different nature of the physical system, but also because the potential pollution sources are so diverse and not well understood. For example, while it is relatively easy to project point source discharges of conventional pollutants from municipal sewage treatment plants based on expected growth in population, attempts to predict rates at which given pollutants may leach from waste disposal ponds into nearby aquifers are very uncertain.

Finally, unlike surface waters, ground water pollution often is essentially irreversible since ground water is slow moving and biological degradation of contaminants is nonexistent. Because the costs of cleaning up an aquifer are often prohibitive, prevention of contamination generally is the only viable alternative.

In order to deal with the problems of ground water protection, EPA proposed a Ground Water Protection Strategy in 1980 to serve as the agency's policy framework, particularly in establishing coordinated relationshps with the states. Although this policy had not been adopted by EPA by the end of 1981, it is useful to briefly consider it to better understand the issues involved. The objectives of this ground water protection strategy were (U.S., EPA, Off. of Drinking Water, 1980):

By 1985

- To initiate ground water protection strategies in all states and to develop the necessary institutional capacities at the state and local levels.
- To implement fully the currently enacted federal regulatory programs which affect ground water, e.g., RCRA, Underground Injection Control Program, and Superfund.
- To launch efforts to evaluate ground water quality, to ameliorate the most hazardous conditions discovered, and to implement methods of managing newly discovered ground water contamination problems.
- To provide a process whereby states and local governments and the public can set priorities among competing activities which may use or contaminate ground water.

By 1990

- To ensure that appropriate levels of protection are being provided for the ground water resources in each state and that each state has a complete program which has been fully implemented to manage all ground water.

One of the key, and most controversial, management approaches in the proposed strategy was the concept of ground water classification. The premise of a classification system is that different levels of protection should be provided to ground water according to a number of factors. The classification process should identify high priority ground water areas for high levels of protection and assist in identifying those areas least environmentally sensitive for siting potentially polluting activities. Classification decisions about the appropriate levels of protection would be based on such factors as: present and projected future uses; current quality; yield, or volume of water available; availability of alternative water supplies; and vulnerability to contamination. Until a classification system is developed and adopted, EPA is to maintain a policy of protecting ground water which is currently of drinking water quality or better (U.S., EPA, Off. of Drinking Water, 1980).

It has been suggested that this classification approach has too many uncertainties and should not be undertaken until the consequences are reasonably well understood (Howells, 1981). Until then, it was argued that national and state policies should provide for the protection of all high-quality and sole-source ground waters irrespective of projected uses. Reasons for taking issue with the classification approach included: (1) there is too much uncertainty involved in projecting future uses and decisions affecting ground water quality are essentially irreversible; (2) the problems of applying this concept to the discharge of toxic substances in ground waters is extremely complex and probably would best be handled by a no-discharge policy; (3) ground water systems are very complex and there would be serious practical implementation questions (e.g., how are multiple aquifers involving water-table aquifers and continued deeper aquifers to be handled where all underlie a land use in question?) (Howells, 1981).

A primary thrust of EPA's Proposed Ground Water Protection Strategy was the encouragement of states to develop their own programs. At the present time, Sunbelt states have widely varying programs for protecting ground water quality, as revealed in a recent review by the U.S. Water Resources Council[1] (U.S., WRC,

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[1] Chapter 13 provides a similar review of state ground water management programs (i.e., programs governing allocation and use).

1981). Table 14-10 summarizes the ground water protection programs of our thirteen states in four categories:

- Regulatory Program: Identifies the major sources of contamination regulated either under specific legislation (e.g., hazardous wastes, surface mining, or deep well injection) or under an agency's broad water quality regulatory authority. Aimed at regulating the identified source of contamination through a permit process or prohibition of the activity;

- Classification System: Classifies aquifers according to current or projected use and confers a degree of protection necessary to maintain the designated use;

- Ground Water Quality Standards: Specifies standards designed to protect the designated classification (if any) or specifies drinking water standards adopted solely to protect public health unrelated to any classification system; and

- Land Use Controls: Addresses state and local land use programs which affect siting decisions. State regulations, local zoning ordinances, and federal designation of sole source aquifers are included.

As indicated in the table, all of the Sunbelt states regulate at least some potential sources of ground water contamination, with two states (New Mexico and North Carolina) controlling all sources of ground water contamination. Two states (New Mexico and Florida) have adopted ground water classification systems, although three others (Kentucky, North Carolina, and South Carolina) are in the process of developing such a program. Only four states have adopted ground water (or drinking water) quality standards, but several others are in the process. Finally, only Florida has any broad land-use control program to protect aquifers. Although authority is granted to local governments to use zoning, only Dade County has done so. From this table, Florida and New Mexico have the most comprehensive ground water protection programs. This is not surprising given the critical nature of this resource to these two areas.

As the Sunbelt continues to grow, many activities will increase the threat to ground waters. These include the need to dispose of larger quantities of hazardous wastes from the expanding industrial base, the increased use of septic tanks in nonurban areas (including recreational areas), increased oil and gas well drilling (especially in Region 6), increased pumping of aquifers to meet the needs of an expanding populaton, increased waste generation from air and water pollution controls (e.g., sewage sludge and flue gas desulfurization sludge), and increased

TABLE 14-10: STATE GROUND WATER PROTECTION PROGRAMS

State	Regulatory Program	Classification System	Ground Water Quality Standards	Land Use Controls
Alabama	Deep well injection of industrial wastes, landfills and other surface activities		Dept. of Public Health considering drinking water standards	
Arkansas	Landfills, surface mining, septic tanks, and deep well injection of oil and gas brine	Governor's Task Force on Water Policy may recommend classifcation system		
Florida	Deep well injection of industrial wastes, salt water intrusion, landfills, and surface mining	Dept. of Environmental Regulation has classified aquifers	Ground water quality standards adopted to protect drinking water (under revision)	Local gov'ts authorized to use zoning to protect aquifers--Dade County has done so; Biscayne Aquifer sole source
Georgia	Deep well injection of industrial wastes, oil and gas brine, underground storage, surface discharges, and landfills		Drinking water standards adopted	
Kentucky	Landfills and surface mining	Division of Water developing use designations	Division of Water developing ground water quality standards on basis of use	
Louisiana	Landfills, surface mining, deep well injection of industrial wastes, and salt water intrusion			

(continued)

TABLE 14-10: (continued)

State	Regulatory Program	Classification System	Ground Water Quality Standards	Land Use Controls
Mississippi	Deep well injection of industrial wastes and oil and gas brine, and landfills		Drinking water standards being developed	
New Mexico	All sources of ground water contamination	Aquifers have been classified by Water Quality Control Commission	Water Quality Control Commission adopted standards to protect ground water of 10,000 mg/l or less of TDS for domestic and agricultural use	
North Carolina	All sources of ground water contamination	Aquifers are being classified		
Oklahoma	Deep well injection of industrial wastes, landfills, surface mining, and salt water intrusion		Drinking water standards adopted; ground water protection standards are being planned	
South Carolina	Landfills, surface mining, and other surface activities	Aquifers are beginning to be classified	General water quality standards are being adopted	
Tennessee	Deep well injection of industrial wastes, landfills, and surface mining			
Texas	Waste water discharges, solid and hazardous wastes, deep well injection of industrial wastes, and oil and gas brine		Dept. of Health has adopted drinking water standards	Water Commission prohibits certain activities over Edwards Aquifer--sole source aquifer

levels of other land-disturbing activities (e.g., coal mining and agricultural production). Mitigating these threats is the fact that the environmental community and the public-at-large have begun to recognize these problems and take appropriate actions. For example, EPA has substantially increased its research effort dealing with ground water, including establishing a National Center for Ground Water Research. As shown in Table 14-10, many of the states are improving their ground water protection programs. One expert expressed the opinion that while the media has recently focused much attention on pollution of water and its adverse health effects, there is still reason for optimism. According to Jay Lehr, Editor of the Water Well Journal (1981):

> ....While ground water pollution is widespread, all scientists will agree that we have polluted less than one percent of all ground water supplies and exalt in the fact that activities are now moving forward to eliminate the sources of existing pollution. Some ground water supplies will be cleansed, some will be abandoned and most pollution sources will be eliminated. By the end of this decade, we can expect 97 percent of all ground water to remain in excellent shape and be well-protected for future generations....You see, while the media is just now deciding that the sky is falling, most of the community of hydrogeologic scientists are celebrating the fact that the nation has finally recognized the fabulous potential of our ground water resources and the malevolent forces which endanger it. There exists at last the potential for eliminating the danger and maximizing the extent to which we utilize this vast and misunderstood resource.

14.4 SUMMARY

Three categories of water quality problems and issues have been discussed in this chapter: point source pollution, nonpoint source pollution, and ground water protection. For each of these categories, Table 14-11 summarizes major causal factors, the nature and seriousness of the problem, and associated policy concerns.

Two competing pressures will interact to affect the future of water quality in the Sunbelt. On the positive side, the extensive pollution control programs developed largely in the 1970's under the federal CWA and various state programs are only recently beginning to have an impact. As these efforts continue to take effect, water quality will improve greatly, as it has already in many local areas. Thus, even with population and industrial growth, the discharge of some pollutants should decline. Also, realization of many of the threats to ground water quality has

TABLE 14-11: PROBLEM CHARACTERIZATION MATRIX: WATER QUALITY

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problems and Issues
Point source pollution	Population growth (BOD, nutrients, suspended solids) Industrial growth - Pulp and Paper Mills - Chemicals - Petroleum Refining - Primary Metals - Fabricated Metals - etc.	• Human Health • Ecological • Economic • Aesthetic	Both a current problem and a serious future problem as population and industry grow.	Currently a widespread problem. Municipal point sources seriously affect 91 and 100 percent of the basins in the Southeast and Southcentral regions respectively. Industrial point sources seriously affect 74 and 70 percent of the basins in the Southeast and Southcentral regions respectively.	By meeting planned discharge standards, projections indicate total discharges will decline in the future for some pollutants, but will increase for others. However, such projections are uncertain and few studies have attempted to project long-term water quality trends. Also, the economic costs of meeting existing or planned standards will be high.	• It may not be possible to meet existing or planned water quality standards in some areas with concentrated industrial population growth and/or low stream flows. • There is uncertainty as to the future federal role in assisting municipalities in constructing sewage treatment plants. • Water quality standards and monitoring networks do not adequately address toxic pollutants in most states.
Nonpoint source pollution	Agricultural runoff Urban runoff Septic tanks Mining runoff Silvicultural runoff Hazardous material spills	• Human Health • Ecological • Economic • Aesthetic	Both a current problem and a future problem, especially due to growth in agricultural production and urban development.	Currently a widespread problem. Agricultural runoff seriously affects 62 and 87 percent of the basins in the Southeast and Southcentral regions, respectively; similar figures for urban runoff are 57 and 50 percent.	The most serious pollution problems from nonpoint sources are bacteria, BOD and COD, suspended solids (especially soil erosion), nutrients, pesticides, and, in Region 6, dissolved solids. Nonpoint sources are frequently the most common cause of ground water contamination. As urban population and agricultural production grow, nonpoint source pollution in the Sunbelt is likely to become worse	• Although nonpoint source pollution is widespread and difficult to control, no broad-based regulatory program exists. • More research will be needed to better define the extent of nonpoint source pollution and the effectiveness of alternative controls (e.g., soil conservation practices and integrated pest management).

(continued)

TABLE 14-11: (Continued)

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problems and Issues
Ground water protection	Petroleum production Overpumping of aquifers Waste disposal Septic tanks Mining	• Human Health • Economic	Once ground water is contaminated, it can be essentially irreversible.	There is no comprehensive data base on ground water quality. However, based on intensive local studies, ground water contamination is more widespread than previously thought (especially low levels of highly toxic chemicals).	Because ground water serves as a major source of drinking water, recent discoveries of trace levels of highly toxic pollutants in these resources creates serious human health concerns.	• Research and regulatory programs to protect vital ground water resources lag several years behind those for surface water. • There is no comprehensive ground water quality monitoring network similar to that for surface water. Economic costs of a large-scale monitoring program would be high. • Although, states currently have the major role in ground water protection programs, there is a wide variation among the states in their current ability to deal with such problems.

increased; expanded research and regulatory programs will help to reduce these threats.

On the negative side, several factors are likely to cause further declines in water quality in some areas. Even with expensive pollution control facilities, point and nonpoint sources will deteriorate water quality in areas of concentrated growth. For example, in several areas of concentrated urban growth in Region 6, stream flow patterns are such that during parts of the year the entire flow may consist mostly of municipal and industrial effluents. In such instances it will be technologically difficult and expensive to meet existing or planned water quality standards. Urban runoff will exacerbate the problems, since this source is especially difficult to control. As agricultural and silvicultural production expands, nonpoint sources of pollution will increase, especially if production expands into marginal lands. However, this will depend on the extent to which various control measures (e.g., soil conservation practices and integrated pest management) are applied and their effectiveness. Considerably more research is required in this area. In addition, many other projected growth activities could exacerbate nonpoint source pollution problems. These include expanded coal and lignite mining, oil and gas production, septic tanks, spills of hazardous materials, waste disposal (all types), and various construction projects (e.g., highways and waterways). Finally, increased water consumption can threaten water quality and riparian ecosystems.

There have been very few studies which have attempted to project water quality trends on a regional basis under alternative growth assumptions and levels of pollution control. Considerable effort will be required to balance economic development and the protection of the water resources, which are important to such development over the long term. In some cases, it will not be possible to meet water quality standards under projected growth levels and current regulatory programs will be inadequate to ensure long-term protection of water resources critical to continued growth. Thus, water quality protection will be a key issue facing policymakers concerned with the growth of the Sunbelt over the next two to three decades.

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CHAPTER 15

HAZARDOUS WASTES

HIGHLIGHTS

- Status and Trends

1. The U.S. generates about 4 billion tons of solid waste each year. There is a wide range of estimates as to how much of this is hazardous; one source estimates 41 million tons per year are potentially hazardous and more than half of these wastes are generated in Regions 4 and 6. Hazardous waste generation is expected to double nationwide between 1975 and 2000.

2. Hazardous waste problems are ubiquitous. One source estimates that in our study area there are:

   (a) 200,000 individual sources;

   (b) 2,400 transporters; and

   (c) 7,200 known disposal sites.

3. EPA has estimated that only about 10 percent of all hazardous wastes are currently disposed of in a manner that would meet proposed regulations by the Resource Conservation and Recovery Act. Nearly 50 percent is disposed of in unlined holding ponds, 30 percent in nonsecure landfills, and about 10 percent is either disposed of on land illegally, dumped into sewers, or incinerated without proper controls.

4. The chemicals and allied products industry accounts for most hazardous wastes: 62 percent nationally, 85 percent in Region 4, and 81 percent in Region 6 (in 1980). Other significant sources in Region 6 are petroleum and coal products, accounting for 8 percent of the region's total.

5. As of April 1980, EPA had identified 971 hazardous waste disposal sites in Region 6 that could potentially threaten human health and the environment:

   --183 in Louisiana
   --491 in Texas
   --161 in Arkansas
   -- 74 in Oklahoma
   -- 64 in New Mexico

   Other sites probably exist which have not yet been identified.

6. A recent study comparing waste disposal demands in 1981 with treatment and disposal capacity found that regions 4 and 6 are better off than any other federal region. Regions 4 and 6 have an estimated surplus capacity of 0.21 million and 6.6 million wet metric tons per year, respectively. This compares with Region 5 (the worst off) which has a projected shortage of 489 thousand wet metric tons per year.

- Key Problems and Issues

7. Even if all hazardous waste generation were stopped immediately, there would continue to be ground water contamination problems as wastes which were improperly disposed of in the past leach out and percolate into the ground water system.

8. The RCRA regulations could prove economically hard to bear for small generators. A very important issue will be for local, state, and federal authorities to provide some assistance to these smaller companies to keep them in business. This could include technical assistance, low interest loans, and support of consortia of small generators.

9. Intense public opposition has blocked siting of new hazardous waste management facilities, forestalled expansion of existing facilities and, in several instances, caused operating facilities to be closed. An important issue is what mechanisms at the federal, state, or local level might be used to develop hazardous waste management capabilities to protect public health and the environment.

10. Government generators of hazardous wastes (especially DOD) are important but are often overlooked. DOD is just now beginning to recognize that they will be subject to RCRA regulations. In addition to "typical" government generators (such as Tinker Air Force Base in Oklahoma City, Oklahoma) there are several unique hazardous generators in our study area including White Sands Missile Range, Redstone Arsenal, and the Savannah River Plant.

11. High temperature incineration is a possible solution for many kinds of hazardous wastes. However, air quality regulations may not be adequate to prevent air quality degradation because of the lack of standards for toxic pollutants and the difficulty of monitoring for a wide variety of toxics at very low concentrations.

12. Transportation of hazardous wastes to off-site disposal areas greatly increases the potential for inadvertent releases into the environment through accidents or emergencies. Establishing standards for transporters, without becoming so restrictive as to force them out-of-business, will be an important issue for the region.

13. The concern with hazardous wastes is so new that there are still many data gaps, regulatory uncertainties, and scientific unknowns. One important need is to classify hazardous wastes with respect to degree of hazard, instead of simple qualitative terms.

14. Educational programs are needed to inform industry, federal, state, and local government officials, and the public-at-large of the hazardous waste problem and its economic and environmental consequences.

15. Comprehensive ground water quality monitoring programs are needed to detect contamination from hazardous waste disposal. Such programs exist for air quality and surface water (see Chapter 14).

CHAPTER 15

HAZARDOUS WASTES

15.1 INTRODUCTION

The hazards associated with the disposal of toxic waste did not become widely known until 1978 in the aftermath of the Love Canal incident. However, waste disposal is not a recent problem. The Environmental Protection Agency's (EPA) Office of Solid Waste has estimated that about four billion tons of solid waste are produced every year in the U.S. by industry, agriculture, mining, and municipalities. Of that:

- 3 billion tons are mining waste;
- 475 million tons are agricultural waste;
- 380 million tons are industrial waste;
- 145 million tons are municipal refuse; and
- 55 million tons are sewage sludge.

Of this total, it is estimated that 33 to 48 million tons per year are hazardous (see EPA Journal, 1979; and U.S., EPA, Office of Solid Waste, 1980). Wastes are hazardous if they may cause or significantly contribute to serious illness or death, or if they pose a substantial threat to the environment when improperly managed (see page 15-2).

By 1979, EPA estimated only about 10 percent of the hazardous waste was disposed of in a manner that would meet proposed regulations. They found that about 50 percent was disposed in unlined evaporative holding ponds, 30 percent in nonsecure landfills, and 10 percent was dumped illegally on land or in municipal sewers or incinerated without proper controls (Maugh, 1979, p. 819; and EPA Journal, 1979).

By 1981, EPA had identified 9,300 hazardous waste sites, had carried out 5,900 preliminary assessments, had completed investigations for 2,700, and had taken emergency action for 52 sites. Of the total number of 760,000 producers of hazardous waste, 92 percent produce less than one ton per month and 8 percent produce more than five tons per month. The top 5 percent produce 98 percent of the total of hazardous waste.

This distribution of producers and modes of disposal complicates regulation. Big industrial producers can afford the investment for treatment and disposal either on- or off-site. In contrast, many of the small producers cannot afford the necessary capital for safe disposal. Furthermore, hazardous wastes result from the manufacture of many products which are indispensable for agriculture, industry, and households and which are produced in competition among national and foreign firms. Thus, consideration should be given to the costs of regulation on the competitiveness of U.S. firms in both the national and the international markets.

Another complication arises from the fact that safe disposal of hazardous waste involves both environmental and occupational hazards in its transport, handling, and chemical treatment. Decisions on how to best control hazardous substances need to consider not only the economic costs, but also the extent to which a hazardous waste disposal industry should be encouraged, the role that states and local authorities should play, and how to balance risks of disposal with those of handling and transport.

15.2 CURRENT STATUS

15.2.1 The Regulatory System

Several federal and state laws regulate the generation, transportation, and disposal of hazardous waste. The most important of these is the 1976 Resource Conservation and Recovery Act (RCRA). RCRA deals broadly with solid waste management, as summarized in Table 15-1. Subtitle C of RCRA deals specifically with hazardous waste, which is defined as:

> A solid waste, or combination of solid wastes which, because of its quantity, concentration, physical, chemical, or infectious characteristics may:
>
> 1. Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
>
> 2. Pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Subtitle C requires EPA to issue regulations for the purpose of monitoring and controlling hazardous wastes from the point of generation to ultimate disposal. The regulations under RCRA cover

TABLE 15-1: MAJOR PROVISIONS OF THE RESOURCE CONSERVATION AND RECOVERY ACT OF 1976

Subtitle	Description
General Provisions	Defines objectives: to promote protection of health and environment; to conserve resources by assisting state and local governments and interstate agencies in development of solid waste disposal plans; to require closing or upgrading of all open dumps; to regulate closely all hazardous waste and provide guidelines for solid waste management and resource recovery/conservation systems.
Office of Solid Wastes	Establishes an Office of Solid Waste in EPA; authorizes technical and financial assistance to states or regional agencies in the development of solid and hazardous waste management programs.
Hazardous Waste Management	Requires EPA to promulgate criteria for identifying the characteristics of hazardous waste and an initial list of hazardous substances. It must also promulgate standards for generators, transporters, and operators of disposal facilities of hazardous waste. Regulations concerning permits and state take-over of hazardous waste programs are provided for.
State or Regional Solid Waste Plans	Requires EPA to promulgate regulations that contain the guidelines to be followed in developing state or regional solid waste management programs. The plans must satisfy minimum requirements including but not limited to the closing or upgrading of all open dumps, the disposal of solid waste in sanitary landfills, and the repeal of state laws prohibiting local governments from entering long-term contracts for the supply of solid waste to resource recovery facilities.
Duties of Secretary of Commerce	To promulgate guidelines for classifying material recovered from solid wastes, identify the geographic markets for recovered material, identify economic and technological barriers to the use of recovered materials, and encourage the development of new uses for recovered material.
Federal Responsibilities	Specifies that federal facilities are to comply in ways identical to private entities.
Miscellaneous	Contains citizen suit provisions, whereby any person can sue any other person (including the United States) alleged to be in violation of any permit or standard.
Research, Development, Demonstration, and Information	Provides guidelines for establishing a research, development and demonstration program covering all facets of solid and hazardous waste management, and resource conservation and recovery.

Source: RCRA, 1976.

the three stages in the hazardous waste life cycle: generation; transportation; and storage, treatment, and disposal. (See Appendix A for a more detailed description.) The regulations (1) specify means to identify hazardous wastes (Section 3001); (2) describe detailed procedures to be followed by generators in labeling, storing, and packaging wastes; (3) require transporters to comply with manifest and delivery requirements to assure all wastes are delivered to the designated permitted disposal facility; and (4) set standards for owners and operators of hazardous waste treatment, storage, and disposal facilities. EPA is taking a three-phase approach in developing these regulations. Regulations and guidelines as required in the act were proposed between February 1978 and February 1979 (EPA Journal, 1979). In response to comments on and reviews of these initial regulations, Phase 1 regulations were issued in May 1980, which took effect November 19, 1980. A second phase of regulations, to have been added in January 1981, would have identified additional hazardous wastes and set technical standards for the issuance of permits. A third phase of regulations would be to resolve technical issues and set more definitive engineering control standards (Booz Allen Hamilton, and Putnam, Hayes & Bartlett 1980). Phases two and three have been postponed by the Reagan administration.

In December 1980, Congress passed the Comprehensive Environmental Response, Liability and Compensation Act, commonly known as the "superfund," which set up a 1.6 billion dollar fund to pay for cleaning up old, abandoned, potentially dangerous dump sites (like Love Canal) and emergencies resulting from chemical spills. This act recognized that even with RCRA, there was a very limited government capacity to respond to emergencies, since responsible parties often could not be identified and they are often unable to pay for clean-up. In addition, forcing companies to pay for spills often involves lengthy judicial procedures (U.S., CEQ, 1979, p. 186). Part of the fund (87.5 percent) will be financed over the next five years by a tax on oil and specified chemicals, and the rest will be appropriated.

Another bill, the "Environmental Emergency Response Act" was introduced in 1979 but was not passed. This bill would have allowed for compensation to individuals who suffered economic or health damage from exposure to spills or hazardous waste dump sites. One of the arguments against this bill was that compensation could legally be required only when a sufficient relationship is shown between harm and particular activities. An individual claiming injury must establish that a particular party was negligent in causing the injury. In a pollution related lawsuit, this would require that exposure to a pollutant emitted by a specific source caused a specific injury or disease. While the causes of some diseases are readily identified, there may be several sources of exposure. Also some environmentally related illnesses are clinically indistinguishable from diseases of nonenvironmental origin or from the aging process (National Journal, 1980; U.S., CEQ, 1980, p. 230).

In addition to RCRA and the superfund, there are several other federal laws which affect hazardous waste management:

- Federal Insecticide, Fungicide, and Rodenticide Act (as amended in 1978), which regulates the use of pesticides and the safe disposal of ones whose registration is cancelled or suspended.

- Marine Protection, Research, and Sanctuaries Act (as amended in 1974), which regulates ocean dumping.

- Toxic Substances Control Act of 1976, which is essentially a "gap-filling" measure that defers to the other laws where possible. Generally, this law authorizes EPA to obtain production and test data on chemical substances from industry and to regulate these substances as necessary.

- Hazardous Materials Transportation Act of 1974, which authorizes the Department of Transportation to issue regulations for procedures to be followed when transporting hazardous materials.

Most states have addressed the hazardous waste problem to some degree--as of 1978, control ranged from very minimal to comprehensive programs (U.S., EPA, Off. of Solid Waste, 1980, p. 2-18). The majority of states have exercised their authority over hazardous wastes under their existing solid waste legislation, typically with broadly worded provisions that do not deal explicitly with hazardous wastes. Thus, enforcement and management are largely determined by the individual state regulatory authority. At least 16 states have specific laws dealing with hazardous wastes. Six of these are in the Sunbelt: Alabama, Louisiana, New Mexico, Oklahoma, South Carolina, and Tennessee.

As with the Clean Water Act, and the Clean Air Act, RCRA allows states to take over the permit issuance function if they have approved programs. Section 3011 of RCRA authorized 25 million dollars for fiscal years 1978 and 1979 to assist the states in developing and implementing authorized hazardous waste programs. States with hazardous waste management programs already in effect may apply to EPA for interim authorization, for up to 2 years, to administer the permit program under their existing laws (Duvel and Gaines, 1979, p. 73.) In Region 4, each state except Florida is pursuing, and is likely to receive, interim authorization (U.S., EPA, Region 4, 1980).

15.2.2 Hazardous Waste Generation and Accidents

A. Generation

It has been estimated that the Sunbelt contains approximately 200,000 individual generators, 2,400 transporters, and 7,200 known disposal sites of hazardous wastes (Boatright, 1980). Region 6 produces about 25 percent of the total U.S. output of hazardous waste and includes 10 percent of the generators. Region 4 produces about 16 percent and includes about 15 percent of the generators. In total, the Sunbelt produces about 41 percent of the nation's hazardous waste and has about 25 percent of the generators. Only Region 5, which has 23 percent of the wastes and 21 percent of the generators, is comparable to regions 4 and 6.

The primary reason for such large volumes of hazardous waste production in the Sunbelt is that the industries which are responsible for generating most of the waste nationally are among the top industries in the South. Primary metals, organic and inorganic chemicals and electroplating account for 83 percent of industrial wastes nationally. The importance of these industries to the South is described in detail in Chapter 4 (Industrial Trends) and Chapter 7 (Chemicals) and summarized briefly in section 15.3.1 below.

Tables 15-2 and 15-3 present data on hazardous waste generation by region and industrial source. The data in Table 15-2 are estimates for 1975 from EPA's Office of Solid Waste. In Table 15-3, 1980 data are presented from a study by Booz Allen Hamilton and Putnam, Hayes & Bartlett. The EPA data show that 47.5 million tons of hazardous wastes are produced nationally. Of this, the Sunbelt accounts for 27 percent--17 percent in Region 4, and 10 percent in Region 6. In contrast, the data in Table 15-3 show that of the 41 million tons total in 1980, over 50 percent came from the Sunbelt--almost equally divided between the two regions.

Both sources agree that chemicals and allied products (SIC 28) account for the large volume of hazardous wastes nationally, and particularly in the study area. In Table 15-2, these products account for 60 percent nationally, 72 percent in Region 4, and 68 percent in Region 6. In comparison, Table 15-3 shows chemicals and allied products contributing 62 percent nationally, 85 percent in Region 4, and 81 percent in Region 6. A second significant source in Region 6 is petroleum and coal products (SIC 29) which accounts for 8 percent of the total in Region 6.

One problem in estimating quantities of hazardous wastes is in defining what constitutes a hazardous waste. In the report from which Table 15-3 is derived, three subcategories of hazardous wastes are identified:

TABLE 15-2: SUMMARY OF HAZARDOUS WASTE GENERATED BY FEDERAL REGION, 1975[a] (thousands of metric tons per year)

Industry (SIC)	Federal Region											Percent of	
	1	2	3	4	5	6	7	8	9	10	Total	Total	Ranking
Food & Kindred Products (20)	10.0	25.0	30.0	45.0	70.0	30.0	25.0	9.0	35.0	15.0	290	0.5	10
Textile Mill Products (22)	10.0	10.0	15.0	100.0	3.5	2.5	0.5	<0.5	2.0	0.5	140	0.5	15
Apparel & Other Textile Products (23)	7.0	30.0	20.0	40.0	10.0	10.0	4.0	1.0	10.0	10.0	130	0.5	16
Lumber & Wood Products (24)	4.0	3.0	7.0	20.0	10.0	8.0	2.5	2.0	8.5	20.0	80	<0.5	18
Furniture & Fixtures (25)	9.5	20.0	25.0	75.0	50.0	15.0	7.5	1.5	25.0	2.5	240	0.5	12
Paper & Allied Products (26)	290.0	350.0	290.0	530.0	760.0	200.0	120.0	10.0	180.0	130.0	2,870	6.0	4
Printing & Publishing (27)	9.0	20.0	15.0	15.0	30.0	8.0	8.5	3.0	10.0	2.5	130	0.5	17
Chemicals & Allied Products (28)	1,060.0	5,290.0	3,600.0	5,920.0	5,770.0	3,270.0	1,230.0	170.0	1,880.0	460.0	28,700	60.0	1
Petroleum & Coal Products (29)	25.0	95.0	85.0	50.0	160.0	330.0	45.0	30.0	110.0	20.0	950	2.0	7
Rubber & Misc. Plastic Products (30)	20.0	25.0	20.0	35.0	75.0	15.0	10.0	2.0	20.0	2.0	220	0.5	13

(continued)

TABLE 15-2: (Continued)

Industry (SIC)	Federal Region 1	2	3	4	5	6	7	8	9	10	Total	Percent of Total	Ranking
Leather & Leather Products (31)	130.0	95.0	70.0	90.0	120.0	35.0	85.0	8.5	10.0	1.5	640	1.5	9
Stone, Clay, & Glass Products (32)	65.0	160.0	210.0	230.0	350.0	120.0	60.0	35.0	130.0	30.0	1,390	3.0	6
Primary Metal Industries (33)	140.0	290.0	870.0	350.0	1,520.0	190.0	110.0	75.0	200.0	95.0	3,830	8.0	3
Fabricated Metal Products (34)	140.0	170.0	180.0	180.0	700.0	150.0	85.0	20.0	160.0	25.0	1,800	4.0	5
Machinery, Except Electrical (35)	370.0	450.0	400.0	420.0	1,830.0	350.0	290.0	80.0	400.0	60.0	4,650	10.0	2
Electrical & Electronic Equipment (36)	20.0	30.0	20.0	25.0	55.0	10.0	9.0	1.5	25.0	1.0	200	0.5	14
Transportation Equipment (37)	65.0	55.0	60.0	80.0	350.0	60.0	60.0	10.0	150.0	45.0	940	2.0	8
Instruments & Related Products (38)	10.0	15.0	5.5	4.0	15.0	2.0	2.0	1.5	8.0	1.5	65	<0.5	19
Miscellaneous Manufacturing Industries (39)	40.0	55.0	20.0	35.0	60.0	15.0	10.0	6.0	20.0	5.0	270	0.5	11
Total[b]	2,440.0	7,190.0	5,940.0	8,240.0	11,900.0	4,810.0	2,170.0	470.0	3,380.0	920.0	47,500		
Percent of Total	5	15	13	17	25	10	5	1	7	2			

Source: U.S., EPA, Off. of Solid Waste, 1980.

[a] These numbers are estimated based upon the generation factors as derived in Appendix B.

[b] Totals may not balance due to rounding of numbers.

TABLE 15-3: 1980 INDUSTRIAL HAZARDOUS WASTE GENERATION BY INDUSTRY, BY FEDERAL REGION (thousands of wet metric tons)

Industry (SIC)	Total	Federal Region 1	2	3	4	5	6	7	8	9	10
Textile Mill Products (22)	203	27	24	4	132	10	6	0	0	0	0
Lumber & Wood Products (24)	87	4	3	7	20	10	8	3	2	9	21
Furniture & Fixtures (25)	36	2	4	4	9	7	2	2	0	5	1
Paper & Allied Products (26)	1,295	130	272	130	156	324	77	52	13	117	25
Printing & Publishing (27)	154	11	25	19	19	38	10	11	4	13	3
Chemicals & Allied Products (28)	25,509	185	1,497	2,515	8,763	1,870	8,577	553	1	1,426	123
Industrial Inorganic Chemicals	8,072	0	13	510	5,723	646	64	323	0	794	0
Plastics Materials, Synthetics	769	31	108	92	192	131	131	8	0	38	38
Drugs	106	4	54	11	8	22	0	2	0	4	0
Other Chemicals	3,364	138	614	430	688	699	360	131	0	239	66
Paints and Allied Products	125	3	19	11	20	37	8	8	1	17	1
Industrial Organic Chems. and Agric. Chems., N.E.C.	13,066	9	689	1,459	2,130	333	8,014	81	0	333	18
Explosives	7	0	0	2	2	2	0	0	0	1	0
Petroleum & Coal Products (29)	2,119	0	122	165	90	384	878	99	61	258	61
Petroleum Refining	1,901	0	76	152	57	323	836	95	57	247	57
Petroleum Re-refining	218	0	46	13	33	61	42	4	4	11	4
Rubber and Misc. Plastics (30)	249	22	28	22	39	83	17	11	2	22	2
Leather & Leather Tanning (31)	474	156	57	24	14	137	0	38	5	38	5
Stone, Clay, & Glass Production (32)	17	1	2	1	3	4	2	1	1	2	1
Primary Metal Industries (33)	4,061	2	185	791	434	1,348	452	74	109	101	65
Ferrous Metals	2,330	0	117	652	163	1,118	47	0	70	47	16
Nonferrous Metals	1,731	2	68	139	271	230	405	74	39	54	49

(continued)

TABLE 15-3: (continued)

		Federal Region									
Industry (SIC)	Total	1	2	3	4	5	6	7	8	9	10
Fabricated Metal Products (34)	1,997	204	212	172	172	781	137	96	28	164	31
Machinery, Except Electrical (35)	322	26	31	28	29	127	24	20	6	28	4
Electric & Electronic Equip. (36)	1,093	67	156	183	82	334	65	28	5	145	27
Electric, Electronic Equipment	609	62	93	62	77	170	31	28	5	77	3
Batteries	484	5	63	121	5	164	34	0	0	68	24
Transportation Equipment (37)	1,240	86	73	80	106	464	80	80	13	199	60
Instruments & Related Products (38)	90	14	21	8	6	21	3	3	2	11	1
Miscellaneous Manufacturing Industries (39)	318	48	66	24	42	72	18	12	7	24	6
Nonmanufacturing Industries	1,971	119	335	177	237	414	177	118	59	276	59
TOTAL	41,235	1,104	3,113	4,354	10,353	6,428	10,536	1,201	318	2,838	995

Source: Booz Allen Hamilton and Putnam, Hayes, & Bartlett, 1980.

(1) Wastes listed on the EPA Waste List published in May 1980 in Part 261 of the RCRA regulations, and wastes that EPA intends to list (8.3 million tons per year nationally);

(2) Wastes identified as hazardous by RCRA characteristics, but not included on the EPA Hazardous Waste List (20.9 million tons per year nationally); and

(3) Wastes not identified specifically enough (either by type or quantity) to determine their waste category (12 million tons per year nationally).

If such broad definitions are used, a much different picture emerges (over 41 million tons produced annually) than if narrow definitions are used. Thus, an important element in future regulation of hazardous wastes will be the development of standard definitions.

It is also important to recognize the differences in the origins and limitations of the data presented in Tables 15-2 and 15-3. The data in Table 15-2 are based on information from five state survey reports, a survey of EPA Region 10, a list of hazardous waste disposal permits from Illinois, a computerized industrial waste inventory from Maryland, and unpublished data from state files in Texas. Using these sources, generation factors (tons of waste per employee) were developed for each 2-digit SIC code. The factors were then applied to the employment level data for each 2-digit SIC category for each region. Many sources of error exist in such procedures, including:

- Comparability of the data sources (e.g., definitions of "hazardous" as discussed above);
- Possible biases in the coverage of industries (the eight studies covered 14 percent of total U.S. employment in those SIC categories);
- Inaccuracies introduced by the use of 2-digit codes rather than more specific groups at the 3 or 4-digit levels; and
- Potential errors by assuming waste per employee is constant throughout specific industries and independent of geographic region or industry size and technologies used.

For example, leather and leather products (SIC 31) consists of 11 subclasses (four-digit codes) but only one, tanning and finishing (SIC 3111), would be expected to produce large quantities of hazardous wastes. However, the leather tanning industry is not broken out separately in the U.S. Census publications. For chemicals and allied products, the factors calculated for Texas and Mississippi were 65 and 129 metric tons per employee, respectively, while for other states the figures ranged from 0.9 to 35.3 metric tons per employee. EPA concluded that these differences might be partially attributed to the concentration of chemical industry subgroups which produce large volumes of hazardous wastes in the southcentral states (U.S., EPA, Off. of Solid Waste, 1980, p. H-21).

Due to such limitations, these generation factors are most useful when applied to estimating hazardous waste totals for large areas. Table 15-4 presents hazardous waste totals for selected states by 2-digit SIC code (includes our study area except for New Mexico, but also includes Virginia and West Virginia). As indicated, the biggest generator is Texas, with Tennessee in second place, followed by North Carolina, South Carolina, Louisiana, and Florida, each of which produced about the same volume of waste. In every state, chemicals and allied products are the largest source of hazardous waste.

B. Accidents

Hazards resulting from the unsafe dumping of toxic wastes are numerous. The Final Environmental Impact Statement for RCRA describes 300 accidents which have resulted from bad management of hazardous waste. Of these:

- 125 led to underground water pollution, in some cases affecting hundreds of wells;
- 90 led to surface water pollution (creeks, lakes, streams, and rivers). In 15 of these cases large populations of fish were killed;
- 35 involved land pollution, necessitating removal and disposal of substantial quantities of soil;
- 13 led to air pollution and to adverse health effects to people living in neighboring areas;
- 30 caused serious illnesses; and
- 17 resulted in fires.

This evidence suggests that perhaps the most serious danger from the unsafe disposal of hazardous waste is the contamination of ground and surface waters. About 20 percent of these accidents described in the RCRA Environmental Impact Statement have occurred in the Sunbelt states.

TABLE 15-4: HAZARDOUS WASTES GENERATED BY INDUSTRIES GROUPED BY STANDARD INDUSTRIAL CLASSIFICATION BY STATE (thousands of metric tons per year)

Industry (SIC)	AL	AR	FL	GA	KY	LA	MS	NC	OK
Food & Kindred Products (20)	3.5	3.5	6.6	6.6	3.1	4.2	2.5	5.6	2.2
Textile Mill Products (22)	19.8	1.8	2.2	47.4	3.0	8.8	3.4	116.2	0.8
Apparel & Other Textile Products (23)	5.5	1.6	3.4	7.6	2.9	1.0	4.1	7.8	1.3
Lumber & Wood Products (24)	22.8	20.7	15.0	28.2	12.4	16.8	22.5	32.5	3.6
Furniture & Fixtures (25)	0.3	0.7	0.6	0.5	0.3	0.1	0.9	4.8	0.1
Paper & Allied Products (26)	22.6	11.4	18.8	30.5	8.9	17.6	7.2	6.2	2.2
Printing & Publishing (27)	0.7	0.6	2.7	1.4	1.2	0.6	0.4	1.6	1.0
Chemicals & Allied Products (28)	401.2	189.2	859.1	526.1	533.6[a]	1,021.8	211.9	1,177.0	83.3[a]
Petroleum & Coal Products (29)	4.4	14.7	4.4	7.4	7.9	48.6	6.4	3.9	23.1
Rubber & Misc. Plastics Products (30)	2.1	1.0	1.6	2.0	0.9	0.0	0.8	2.6	1.2
Leather & Leather Products (31)	2.7	3.3	1.4	1.2	1.9	0.1[a]	0.8	1.4	0.4
Stone, Clay & Glass Products (32)	37.1	19.8	60.6	67.2	33.0	29.7	31.7	63.9	29.3
Primary Metal Products (33)	61.6	8.1	4.6	16.2	25.2	10.1	3.4	9.6	7.2
Fabricated Metal Products (34)	37.5	22.6	38.7	27.9	30.6	21.1	12.0	32.3	25.7
Machinery, except Electrical (35)	2.9	2.1	4.5	3.4	9.2	2.4	2.3	7.7	6.2
Electric & Electronic Equipment (36)	1.8	2.6	5.4	2.1	4.3	1.2	2.4	5.2	1.7
Transportation Equipment (37)	6.4	1.7	10.3	8.9	4.4	7.7	10.0	3.1	3.4
Instruments & Related Products (38)	0.1	0.2[a]	0.3	0.2[a]	0.2	<0.1	0.1	2.4	0.5[a]
Misc. Manufacturing Industries (39)	0.9	2.4[a]	2.1	6.2	1.2	0.3	1.1	1.9	1.0[a]
Total	633.9	308.0	1,042.3	791.0	684.2	1,192.2	323.9	1,485.7	194.2

(continued)

TABLE 15-4: (continued)

Industry (SIC)	SC	TN	TX	VA	WV	SOUTH	U.S.	% of U.S.
Food & Kindred Products (20)	1.7	5.1	11.1	4.9	0.2	60.8	224.2	27
Textile Mill Products (22)	62.7	12.5	2.5	18.5	0.4	300.0	403.2	74
Apparel & other Textile Products (23)	4.8	7.2	7.7	3.9	0.5	59.3	138.3	43
Lumber & Wood Products (24)	14.6	15.1	29.8	22.3	5.5	261.8	691.3	38
Furniture & Fixtures (25)	0.3	1.6	1.1	1.7	0.1	13.1	29.6	38
Paper & Allied Products (26)	15.4	19.2	21.6	15.1	2.1	198.8	751.3	26
Printing & Publishing (27)	0.5	2.3	4.3	1.6	0.4	19.3	106.5	18
Chemicals & Allied Products (28)	1,033.2	1,097.4	2,320.0	1,195.9	715.3	11,365.0	32,157.8	38
Petroleum & Coal Products (29)	1.5[a]	3.9	169.5	2.0[a]	4.9	302.6	742.1	40.8
Rubber and Misc. Plastics Products (30)	1.5[a]	2.4	3.0	1.6	0.3	21.0	94.2	22
Leather & Leather Products (31)	0.1	7.0	1.2	1.2	0.5	23.2	103.3	22
Stone Clay & Glass Products (32)	40.4	68.0	124.9	38.7	75.0	719.3	2,445.0	29
Primary Metal Products (33)	6.9	24.9	56.4	12.7	35.4	282.3	1,674.0	17
Fabricated Metal Products (34)	13.4	46.3	110.7	23.9	11.6	454.3	2,391.0	19
Machinery, except Electrical (35)	5.1	6.2	23.7	3.8	1.6	81.1	461.4	18
Electric & Electronic Equipment (36)	2.4	4.7	7.8	4.5	0.8	46.9	241.3	19
Transportation Equipment (37)	1.5	6.6	21.5	5.1	1.0	91.6	551.8	17
Instruments & Related Products (38)	1.3	1.0	3.5	1.0[a]	0.3	11.2	96.7	12
Misc. Manufacturing Industries (39)	1.5	3.8	2.8	1.0	0.4	26.6	139.2	19
Total	1,208.8	1,335.2	2,923.1	1,359.4	856.3	14,338.2	43,442.2	35

Source: Copenhaver, Olsen, and Rice, 1978, pp. 374-75.

[a] Derived using the upper range of employees for firms for 1972, U.S. Dept. of Commerce 1976.

15.3 FUTURE TRENDS AND ISSUES

Concerns about hazardous wastes are likely to increase as the Sunbelt continues to experience growth and change. The following section discusses the most significant of these concerns. First, growth projections for key driving forces are summarized. This is followed by a characterization of five issues: managing hazardous wastes, waste disposal capacity, cleaning up old dump sites, siting hazardous waste facilities, and transport of hazardous materials.

15.3.1 Key Driving Forces

Table 15-4 has identified hazardous wastes generated by various industries in the Sunbelt. Based on these data, six industries are key driving forces for hazardous waste generation in the Sunbelt. Ranked in order of percentage of hazardous wastes produced in the South, these industries are: (1) chemicals and allied products (79 percent); (2) stone, clay and glass products (5 percent); (3) fabricated metals (3 percent); (4) petroleum and coal products (2 percent); (5) textile mill products (2 percent); and (6) primary metal production (2 percent). These six industries account for 94 percent of the total wastes generated in the 14 states shown in Table 15-4. Chemicals and allied products is by far the most significant--this industry is the major hazardous waste generator in every state. The other five generators are localized to a few states. Texas (fabricated metals, petroleum products, and primary metals), North Carolina (stone, clay and glass, and textiles), and Tennessee (stone, clay and glass, and fabricated metals) are subject to several sources which produce relatively large volumes of hazardous wastes.

Table 15-5 indicates growth projections for these six driving forces. Each industry is projected to undergo substantial growth through the year 2010--all but textiles are projected to have at least a 200 percent increase in earnings between 1978 and 2010. The largest rates of growth are projected for petroleum and coal products, fabricated metal, and stone, clay and glass. In terms of absolute earnings, textiles, chemicals, and fabricated metal will continue to be the most important of these six industries.

15.3.2 Managing Hazardous Wastes

Future growth in these industries will increase concerns about the management of hazardous wastes. At a general level, these concerns include implementation of RCRA and developing comprehensive systems for controlling the generation, transportation, and disposal of wastes.

TABLE 15-5: GROWTH PROJECTIONS FOR MAJOR HAZARDOUS WASTE GENERATORS

	Projected Growth (earnings--millions of dollars)[a]			
Industry	1978	2000	2010	% Change 1978-2010
Chemicals and Allied Products	2,509	5,816	7,738	+208
Stone, Clay and Glass Products	766	2,941	4,015	+254
Fabricated Metal	1,764	4,811	6,593	+273
Petroleum and Coal Products	124	412	571	+360
Textile Mill Products	4,391	7,222	8,962	+104
Primary Metal	1,590	3,804	5,095	+220

[a] Calculated from U.S., Dept. of Commerce, BEA, 1980. These data are taken from Tables 4-3 and 4-4, Chapter 4, of this report. Figures are millions of 1972 dollars.

RCRA regulations are estimated to involve about 275,000 generators of hazardous wastes and to require about 30,000 permits for treatment, storage, and disposal. Estimates of the cost of complying with these regulations vary widely. EPA estimated the cost of compliance for 17 industries most affected by RCRA to be about 750 million dollars per year. This is about five times as much as is spent by these industries today in hazardous waste management (about 155 million dollars). EPA noted that this would be about 0.28 percent of the annual value of production (267 billion dollars) (EPA Journal, 1979). In contrast, the Chemical Manufacturers Association reported that of 475 industry surface impoundments that were surveyed, only one met RCRA criteria, and that bringing these impoundments into compliance would cost 900 million dollars (Murray, 1979). The financial burden of complying with RCRA will undoubtedly be much heavier for small companies producing small volumes of toxic waste.

Compliance costs are just one of the factors which will make implementation of RCRA difficult. Other factors include uncertainties about definitions of what is hazardous and which situations will require judicial interpretations, and the difficulty in finding sites for hazardous waste disposal facilities. The development of more comprehensive management systems and a hazardous waste disposal industry closely monitored by state and local authorities will make implementation easier.

As suggested in Figure 15-1, a hazardous waste management system would have several components.

A. Waste Generation

The sources of waste have been described earlier. With respect to industrial waste it may originate either from the useless part of raw materials or as a by-product of processing. Wastes can be managed either on-site or off-site. There are several routes for managing waste indicated in Figure 15-1.

B. Waste Exchange, Recycling and Reuse

Environmental legislation increases the cost of waste disposal to the extent that it becomes in many cases less costly for an industry to purify and reuse waste rather than to discard it. For those cases where the waste of an industry is a useful material for another, "waste exchanges" have been established. About 10 percent of the materials listed with waste exchanges change hands in the U.S. as compared to 30 to 40 percent in some European counterparts. Thus, there is potential for further development of this practice. The recycling of solvents, a 200 million dollar business, is expected to become a billion dollar business by 1986 (Senkan and Stauffer, 1981, p. 39).

C. Treatment

Most waste is treated before final disposal, and hazardous waste is required by RCRA to be treated. The wide variety of methods for treatment fall into four main categories:

- Incineration and pyrolysis. Applied to almost all organic waste not contaminated with heavy metals or chlorine. When carried out on specially designed ships or platforms in the high seas, chlorinated organic waste can also be treated in this way.
- Biological methods. Used for organic and some inorganic toxic waste. Aerobic or anaerobic microorganisms decompose the waste in activated sludge systems,

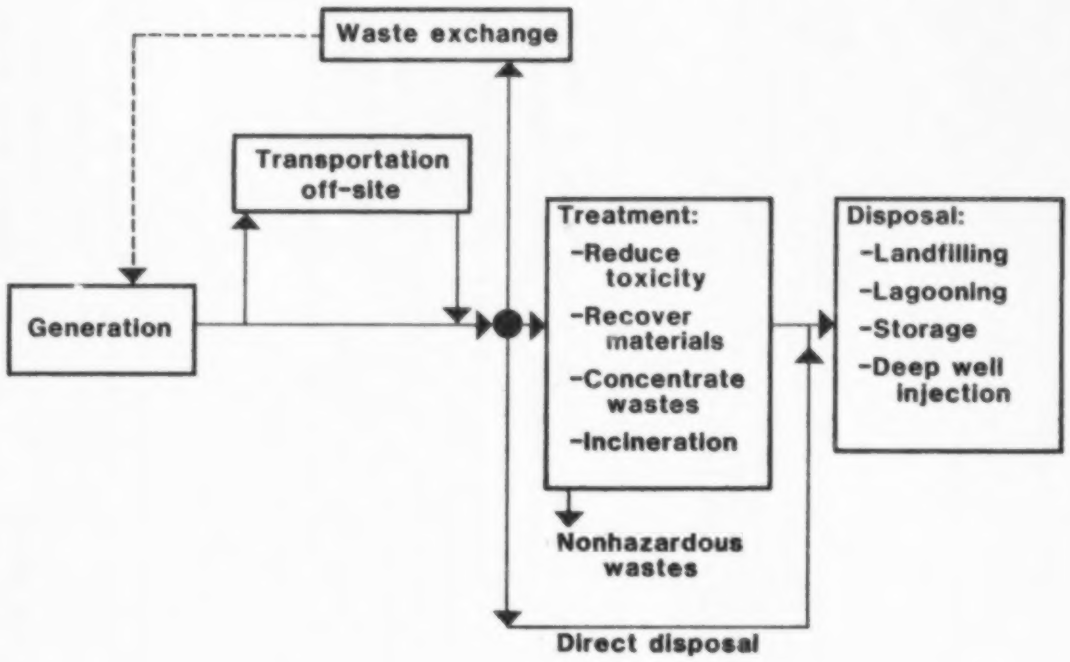

Figure 15-1: Hazardous Waste Management System

aerated lagoons, anaerobic digestion systems and composters.

- Adsorption. Removes organic and some inorganic waste from aqueous streams, activated carbon and resins being the media most widely used.

- Solidification, Encapsulation. Deactivates and immobilizes toxic chemicals by incorporating them into the structure of a stable solid compound like cement, glass, or polymers.

Whether the waste receives treatment or not, the final step is disposal of the residue or of the waste. This may take place in landfills, lagoons, storage or deep well injection.

15.3.3 Waste Management Capacity

A recent EPA study (prepared by Booz Allen Hamilton, Inc., and Putnam, Hayes & Bartlett, Inc.) compared offsite waste treatment and disposal capacity demand in 1981 and concluded that regions 4 and 6 are better off than other regions. According to this report, regions 4 and 6 have an estimated surplus capacity of 0.21 million and 6.6 million wet metric tons per year, respectively. This compares with a deficit of 0.5 million wet metric tons for Region 5 which is the worst off among the 10 regions.

However, these findings should be considered in the light of the impact of the implementation of the RCRA. The technical design and performance standards for hazardous waste treatment facilities, the financial requirements for post closure maintenance practices and the enforcement of proper disposal operations will affect existing facilities. Some of them may also be unable to meet the CWA (1977), CAA (1977), and Safe Drinking Water Act (1974) standards.

Some current practices in disposing of industrial waste may have to be altered, as has happened with the practice of dumping waste in the Gulf of Mexico which was discontinued in 1974. For example, deep well injection of waste will have to be monitored with respect to ground water contamination.

Furthermore, the projected growth of the chemical industry in the Sunbelt (see Chapter 7), the concentration of petrochemical manufactures in the Texas/Louisiana Gulf Coast and inorganic chemical manufactures in Kentucky, Tennessee, and Florida may lead to bottlenecks in the management of hazardous waste unless preventive measures are taken in time.

Another matter of concern is the small number of commercial facilities (off-site) compared to the on-site facilities. In

Region 4 there are 14 commercial and 2,557 on-site facilities. In Region 6 there are 21 and 1,832 respectively. The implementation of RCRA may substantially reduce the number of on-site facilities before commercial capacity is increased to balance the demand.

15.3.4 Cleaning Up Old Dump Sites

Although there is a wide range of estimates of the exact number and their degree of risk, a large number of old hazardous waste dump sites still exist. Some of these are known to have caused or may cause adverse human health effects. As of mid-1979, EPA had identified 151 sites in the United States that pose a potential threat to human health or the environment due to the presence of hazardous wastes (U.S., EPA, ORD, 1980a, p. 520). This list of sites is under continuous review and new sites are being added to the list. One estimate prepared for EPA indicates that as many as 32,000 active or abandoned dump sites may contain hazardous wastes, with more than 800 containing significant quantities of such wastes. Use of an alternative method based on the quantity of hazardous waste generated annually resulted in an estimate of more than 50,000 active and inactive hazardous waste sites (Fred C. Hart Associates, 1979). It was estimated by one study that it would cost 28 to 55 billion dollars to clean up all the inactive dumps (Fred C. Hart Associates, 1979). Although such estimates are preliminary, they do illustrate the magnitude of the problem.

As of April 1980, EPA had identified 971 hazardous waste disposal sites in Region 6 that could potentially threaten human health and the environment. About 50 percent of these are located in Texas (491), with the remainder located in Louisiana (183), Arkansas (161), Oklahoma (74) and New Mexico (64). Other sites probably exist which have not yet been identified (U.S., EPA, ORD, 1980b, p. 27). This situation is an important example of a latent environmental problem. Even if all hazardous waste generation were stopped immediately, there might continue to be a danger of ground water contamination in the future from wastes which have been disposed of improperly. Furthermore, once ground water is polluted it is very difficult, if not impossible, to cleanse (see, for example, Seller and Canter, 1980).

15.3.5 Siting of Hazardous Waste Facilities

The current number of hazardous waste facilities as indicated by the applications to the EPA for interim status is as follows:

	Region 4	
State	On-Site	Off-Site
AL	260	1
FL	690	0
GA	332	1
MS	157	0
NC	408	2
SC	204	3
TN	278	5
KY	228	2
Total	2,557	14

	Region 6	
State	On-Site	Off-Site
AR	113	1
LA	220	5
NM	43	0
OK	110	3
TX	699	12
Total	1,832	21

However gradual, implementation of RCRA will change the structure of the hazardous waste management industry. This will be for both economic reasons (small industrial firms being unable to upgrade their on-site facilities to RCRA standards) and social reasons (local populations objecting to hazardous waste facilities in their neighborhood).

With respect to existing facilities, many small on-site facilities may have to close down if they cannot meet RCRA standards. Some moderately-sized firms with on-site facilities may prefer to discontinue their operation. This may be to improve their relations with surrounding communities rather than for lack of the necessary capital for upgrading their facility. According to the RCRA, hazardous waste management facilities will be required to undergo public hearings before the issuance of a final permit. On-site facilities currently operated by generators are not excluded, hence they may choose to dispose of their waste off-site instead of being subjected to possible legal actions or a negative public image (Yang, n.d.). Implementation of RCRA could lead to three kinds of developments:

(1) Large generators of hazardous waste will upgrade their current on-site facilities to comply with RCRA regulations and avoid paying the extra costs of transport and fees of the hazardous waste management industry. They will also work toward using raw materials and processes which generate less hazardous waste.

(2) Small generators of hazardous waste will close down their on-site facilities which do not meet RCRA standards, or those which may lead to costly court action against objecting communities. They will turn to the hazardous waste management industry for transport and disposal of the waste.

(3) The hazardous waste mangement industry will establish large hazardous waste management facilities to accommodate the demand for its services. For the identification and use of the necessary new sites a close cooperation between state and local authorities and the industry should be developed.

Intense public opposition has blocked siting of new hazardous waste management facilities, forestalled expansion of existing facilities, and, in several instances, caused operating facilities to be closed. A study on the capacity of the hazardous waste management industry concluded that public opposition was the most critical factor affecting future capacity (Booz Allen Hamilton, and Putnam, Hayes & Bartlett, 1980, p. VI-1).

Permit issuance legislation differs among states, hence the problems that state and local authorities and industry will meet will not be the same across the Sunbelt. Existing legislation falls into three main groups:

(1) Local Authorities have the final say in all facets of the siting procedure. The effect of complete local authority upon the supply of hazardous waste management facilities is often negative since the states cannot overrule any strong public opposition and action. Alabama, South Carolina, Arkansas, Oklahoma and New Mexico belong to this class of states.

(2) State Legislatures have some degree of preemptive authority over local government in overriding local laws and regulations restricting the siting of hazardous waste management facilities. The degree of that authority varies from complete state control over all decisions of local authorities (North Carolina), to limited preemptive control in special instances. Thus, in Florida the state's Department of Natural Resources and the Regional Planning Council may approve deviations from local zoning for the siting of a hazardous waste management facility if it fulfills specific environmental, economic and technical criteria. Georgia's Department of Natural Resources has preemptive authority over all local decisions, with the exception of local zoning ordinances. Mississippi's Department of Health is granted preemptive authority over a local ordinance if the proposed site is within an industrial zone. Texas has a preemptive authority similar to Mississippi's.

In general, this kind of limited preemptive authority facilitates the siting of hazardous waste management facilities because it allows for the consideration of both local and regional interests and of social, economic, and environmental factors.

(3) State Boards offer a third option for siting hazardous waste management facilities. The preemptive rights of state governments over local authorities have come into question by the public and, in some cases, the dispute has been taken to the courts. Establishing state boards for siting hazardous waste management facilities is an intermediate solution which seems to offer some advantages in reducing polarization between state and local authorities. Tennessee established such a board, consisting of persons with technical expertise in agriculture, geology, and engineering; representatives from generating industries and environmental and local interest groups; and ex officio members from the departments of Public Health, State Planning, and Economic and Community Development. The board mandate includes the development of a hazardous waste management plan for the state. Its permitting authority is limited to off-site facilities.

Siting boards have a positive impact on the supply of facilities because they provide a mechanism for local input into the siting process. Georgia and Alabama have considered establishing similar boards.

Apart from choosing a mechanism for siting hazardous waste management facilities, information on hazardous waste management for federal, regional, and local authorities, industry, and the public at large is an important issue. Unfortunately, much of the coverage by the media of hazardous waste disposal and transport incidents confuses, rather than clarifies the issues. There is a need for disseminating factual information to the public to help them identify the risks and the policies that should be employed to deal with them.

15.3.6 Transport of Hazardous Materials and Wastes

Transporting hazardous wastes to off-site disposal areas increases substantially the potential for inadvertant releases of the wastes into the environment through accidents or emergencies such as shocks, fires, punctures, crushing and immersion. Since transporters use trains, trucks, and barges to ship hazardous wastes over varied routes, a wide range of potential effects from inadvertent releases of the wastes exists. The extent of damage will depend on such factors as the characteristics of the wastes (e.g., compressed gases, solids, etc.), the quantities released, the media of dispersion (e.g., air, water, land), and the proximity to population centers.

Under the Hazardous Materials Transportation Act of 1974, the U.S. Department of Transportation is responsible for issuing regulations on procedures for transporting hazardous materials. However, a review of 29 major railroad and highway accident reports (22 prepared by the National Transportation Safety Board and 7 by EPA) from 1968 to 1980 revealed that little attention was given either to immediate impacts on air, water, or land pollution or to protective measures to preclude long-term contamination (Canter, 1980). Seventeen of the 29 reports dealt with accidents that occurred in Regions 4 and 6.

Under Section 3003 of RCRA, EPA has responsibility for establishing criteria and standards for hazardous waste transporters. Yet, identifying these transporters and monitoring their pickups, routes, distances, and disposals is a major undertaking and one which is still not complete. One source estimates that the study area has as many as 2,400 individual transporters. A key policy issue will be how to establish standards for transporters without becoming so restrictive as to force them out of business.

The implementation of EPA's manifest system will help to secure the off-site safe disposal of hazardous waste. The manifest is a shipping document indicating the origin, destination, type, and volume of waste and contains certification from each party that the waste is properly packaged and characterized. All wastes in transit from the generator to a hazardous waste management facility must be accompanied by a manifest, and the hazardous waste management facility must return a signed copy to the generator showing that the material has been received. EPA requires notification by the generator only if he has not received the signed copy of the manifest within 45 days from the shipment.

Although federal agencies have the major responsibility for transport regulations, state and local governments also have a stake in the issue of hazardous waste transport because of their involvement in maintaining highways and roads, supplying and training emergency personnel, etc.

The trend toward more off-site disposal of hazardous waste as a result of the enforcement of the RCRA coupled with the projected growth of the chemical, energy, and other manufacturing industries in the South, will lead to substantial increases in the volume of hazardous waste transported and hence to the risk and occurrence of accidents.

Cooperation of state and local authorities and industry will be needed to establish hazardous waste management facility networks. Such networks need to consider the necessary capacity needed to allow for safe disposal and for the growth of the industry. In addition, tradeoffs between on-site and off-site disposal need to be considered and networks which allow hazardous wastes to be moved with the least possible probability of accidents need to be established.

15.4 SUMMARY

Table 15-6 summarizes the five principal concerns with hazardous wastes in the Sunbelt. The primary causes of these concerns are growth in several manufacturing industries throughout the Sunbelt. Chemicals, stone, clay and glass, fabricated metals, petroleum and coal products, textiles, and primary metal production, generate 94 percent of the hazardous wastes produced in the Sunbelt. Each of these industries is projected to grow substantially over the next three decades. Of these, the chemical industry is by far the greatest concern--it is the largest generator in every state in our study area. States facing the largest amounts of wastes are Texas, Louisiana, North Carolina, and Tennessee.

Hazardous waste management will become a critical environmental concern for many state and local governments. The lack of federal legislation to regulate hazardous waste management before 1976 led to substandard hazardous waste management facilities or to disposal practices which will have to be replaced. This coincidence of growth of waste output and the reduction and replacement of available facilities will put pressure on state and local authorities and industry to develop systems of hazardous waste management which will allow for the growth of industry but which will not jeopardize public health.

In Texas, Louisiana, Tennessee, and Kentucky a shortage of hazardous waste disposal capacity may occur in the next ten years, particularly if deep well injection of hazardous waste is curtailed. The pressure on the authorities to relax enforcement of RCRA and TSCA could be offset by increasing public reaction to the dangers associated with accidents involving toxic wastes.

One key to solving these problems will be to develop a well-regulated hazardous waste management industry which will cooperate closely with state and local authorities. Policies such as financial incentives for the hazardous waste management industry, identification and development of hazardous waste management facility sites, and adoption of safe working practices call for such cooperation. The federal government and Congress have provided the necessary framework by passing RCRA and TSCA. However, several problems with implementing these laws still must be addressed.

TABLE 15-6: PROBLEM CHARACTERIZATION MATRIX: HAZARDOUS WASTES

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problem
Managing Hazardous Wastes	• Chemicals and allied products • Stone, clay and glass • Fabricated metal • Petroleum and coal products • Textile mill products • Primary metal	• Human health • Ecological • Economic	Short-term problems include implementing RCRA. Comprehensive management of hazardous wastes will be a problem throughout the next several decades because of the growth of key driving forces and the number of unknown disposal sites	Management of wastes from chemical production is pervasive throughout the Sunbelt. Other driving forces are concentrated in Texas, North Carolina, Tennessee, Georgia, and Alabama	This is potentially one of the most serious problems facing the Sunbelt due to the threats to ground water systems and the magnitude of wastes in the Sunbelt	Of particular concern are difficulties in implementing RCRA and dealing with the economic costs of compliance for small firms
Waste Disposal Capacity	• All major waste generators (see above) • Concentration of the chemical industry	• Economic • Political	Long-term problem which will worsen as RCRA is implemented and as industrial growth continues	Pervasive throughout the Sunbelt but of particular concern in the Texas/Louisiana Gulf Coast	Surplus capacity may exist in the Sunbelt, but this capacity will be used over the long-term	Implementation of RCRA may substantially reduce the number of on-site disposal facilities
Cleaning Up Old Sites	• Failure of some generators to properly dispose of wastes in absence of federal regulations	• Human health • Economic	Long-term concern even if all current generators are properly controlled	Pervasiveness is unknown but problem is likely to be concentrated in Texas, Louisiana, and Arkansas	Seriousness is associated with the uncertainty of how many sites exist and the potential for irreversible ground water contamination	Major concern is the costs of cleaning up inactive dumps; costs have been estimated to be as high as $28 to $55 billion

(continued)

TABLE 15-6: (continued)

Impact or Problem	Causal Factors	Type of Problem Created	Duration	Pervasiveness	Magnitude/ Seriousness	Policy Problem
Siting Hazardous Waste Facilities	• Increasing public concern about undesirable facilities combined with rapidly expanding need for more commercial sites	• Political • Economic • Aesthetic	Likely to be a long-term problem (through the turn of the century)	Pervasive throughout Sunbelt because of the interstate transport of wastes to sites throughout the study area	Although this problem may affect large numbers of people throughout the Sunbelt, several mechanisms exist to reduce siting conflicts	Major needs are for more public education about siting choices and, for individual states, choosing the appropriate siting mechanisms
Transport of Hazardous Wastes	• Volume of wastes produced in the South • 2,400 individual transporters • Trend toward off-site disposal	• Human • Ecological • Aesthetic	Present through 2010	Pervasive throughout Sunbelt but particularly serious for transport centers, such as Memphis	Seriousness will increases as more wastes are generated and as public awareness increases	Establishing standards for transporters without creating undue economic problems Possibility of conflicts over the interstate transport of wastes

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APPENDIX 15A

SUMMARY OF RCRA REGULATIONS

Subtitle C of RCRA calls for regulatory action and guidelines in eleven categories. These requirements, as spelled out in the legislation and proposed regulations, are briefly described below:[1]

Section 3001--Identification and Listing of Hazardous Waste:

The regulatory approach taken is to use both identifying characteristics and lists of hazardous wastes, industrial processes, and sources to be brought under regulatory control.

The characteristics used to define hazardous waste are:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

The hazardous waste lists identify specific hazardous wastes (e.g., water-based paint wastes), sources generating hazardous waste (e.g., various departments of hospitals), and processes which generate hazardous waste (e.g., lead slag from lead alkyl production); and indicate for each listed waste or waste stream the reason for its inclusion (e.g., ignitable, corrosive, reactive, toxic). A generator producing a listed waste may be exempted from regulation providing that he could demonstrate that the reason for listing that waste does not apply to his particular waste stream. The methods to be used for such a demonstration include the four identifying characteristics plus tests for low-level radioactivity, infectiousness, mutagenic activity, bioaccumulation potential, and toxicity.

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[1] The regulations described come from U.S., Environmental Protection Agency (EPA), Office of Solid Waste. 1980. Final Environmental Impact Statement Part I for Subtitle C, Resource Conservation and Recovery Act of 1976. Washington, D.C.: U.S., EPA, p. 2-8ff and p. 3-1ff. The final regulations which were to have gone into effect November 19, 1980 may differ. Also, two amendments to RCRA were passed by Congress during 1980.

Section 3002--Standards for Generators of Hazardous Wastes:

The generator requirements apply to those persons or federal agencies, except households, who produce and dispose of more than 100 kilograms (about 220 pounds) per month of wastes identified as hazardous under the Section 3001 regulations. The requirements of the generators of hazardous waste fall within the following broad categories:

- Compliance with the manifest system;
- Reporting
- Recordkeeping
- Containerization
- Labeling
- Furnishing information on general chemical composition

The key aspects of these regulations, and the greatest benefits to be derived, revolve around the development of a manifest system and periodic reporting requirements. The manifest system would require that detailed information regarding each off-site shipment of hazardous wastes is recorded, accompanies the waste during transport, and serves as the basis for filing periodic reports. This system would serve to promote proper delivery and disposal of all hazardous wastes consigned by the generator. Other aspects of these regulations (e.g., containerization and labeling) have been developed to be consistent with existing Department of Transportation (DOT) regulations.

Section 3003--Standards for Transporters of Hazardous Wastes:

The regulations identify those transporters who are subject to regulation and specify requirements that fall within the following broad categories:

- Recordkeeping
- Acceptance and transport of hazardous waste
- Compliance with the manifest
- Delivery of the hazardous waste to the designated, permitted facility
- Emergency situations
- Marking and placarding of vehicles

Many of these controls are currently imposed upon some transporters of hazardous waste by regulations under the

Hazardous Materials Transportation Act.[1] Therefore, the RCRA regulations are designed to be consistent with current DOT regulatory practices; importantly, the RCRA regulations would extend the DOT regulations to intrastate, as well as interstate, transportation of hazardous wastes. The most significant additions to those existing regulations affecting hazardous waste transport are the manifest and delivery requirements that would assure that all hazardous wastes are delivered to the designated permitted facility.

Section 3004--Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities:

These regulations are intended to provide an adequate degree of environmental and public health protection during the treatment, storage, and ultimate disposal of hazardous wastes. These standards include requirements relating to the general aspects of facility operations (i.e., site selection, monitoring, training, security, emergency procedures and contingency plans, inspections, closure, financial requirements, and recordkeeping/reporting) as well as standards applicable to specific types of treatment, storage, and disposal facilities (i.e., storage tanks; containers; landfarms; landfills; surface impoundments; basins; incinerators; and chemical, physical, and biological treatment facilities).

Certain practices that are controlled under other federal acts are not regulated under the treatment, storage, and disposal standards. These practices include underground (deep-well) injection, ocean dumping, discharges to municipal sewer systems, surface discharges under a National Pollution Discharge Elimination System (NPDES) permit, and all treatment, storage, and disposal activities at Publicly Owned Treatment Works (POTW) or by ocean dumping barges and vessels.

The Section 3004 baseline regulations have been divided into five major sections:

- Human Health and Environmental Standards
- General Facility Standards
- Storage Standards
- Treatment and Disposal Standards
- Special Waste Standards

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[1] Title I of Transportation Safety Act of 1974, Pub. L.93-633, 88 Stat. 2156.

The regulations establish a two-tiered system of standards. There are overriding standards for human health and environmental protection which are intended to assure that the design, construction, and operation of hazardous waste facilities does not adversely affect human health or the environment by degrading the ground water, surface water, or air. The human health and environmental standards are used by EPA in drafting and evaluating more specific standards and can be used in designing facilities. While these human health and environmental standards would be legally binding, they are not intended to be directly enforced. They are disigned to be used on a case-by-case basis only where there is reason to believe (e.g., a third party challenge) that the specific standards are insufficient for human health and environmental protection.

General facility standards apply to every type of hazardous waste management facility. For example, they absolutely prohibit locating in an active fault zone or within the 100-year flood plain. Existing facilities that do not meet variance requirements will be forced to close.

In addition to the general facility standards, facilities which store hazardous waste must also comply with general storage standards as well as with standards which apply to storage tanks and storage containers. RCRA's definition of storage implies no discharge to ground water, surface water, or air. The storage standards reflect this intent.

In addition to the general facility standards, facilities which treat or dispose of hazardous waste must also comply with the general treatment/disposal standards. Facilities with incinerators; landfills; surface impoundments; basins; landfarms; or chemical, physical, or biological treatment processes must comply with the standards prescribed under these subsections.

Several waste streams have been identified as being of special concern due to their unique characteristics and the techno-economic uncertainties regarding their disposal. These "special wastes" are high volume wastes which are often disposed of on-site by generators, for which traditional land disposal technology is techno-economically inappropriate, and whose environmental risk is ill-defined. These "special waste" streams include: utility wastes (fly ash, bottom ash), oil drilling muds and brines, cement kiln dusts, phosphate rock mining and processing wastes, uranium mining wastes, and other mining wastes. EPA is planning to promulgate Subtitle C requirements specific to the management of those "special wastes" identified as hazardous under the regulations. However, under the baseline regulations "special wastes" would be subject only to general standards for recordkeeping, reporting, etc. EPA intends to develop any necessary control technology standards for these wastes as soon as possible.

Section 3005--Permits for Treatment, Storage, or Disposal of Hazardous Waste:

These regulations require that all owners or operators of facilities treating, storing or disposing of hazardous wastes obtain a permit prior to facility construction, modification, or operation. The regulations establish standards for permit applications, permit issuance, and permit revocation.

The regulations would also require the circulation of a public notice of any tentative determination to issue, deny, or modify a permit. Within 30 days of publication of the notice, any person would be able to request a public hearing on the determination. The Regional Administrator would decide whether such a hearing is appropriate.

Section 3006--Authorized State Hazardous Waste Programs:

This section requires the promulgation of guidelines to assist states in the development of such programs. Procedures are given for any state to apply for authorization of its hazardous waste program and provides for interim authorization of state programs. Any action taken by a state under an authorized program is given the same force and effect as action taken by the EPA Administrator under Subtitle C. Procedures are also established for withdrawal of authorization by the Administrator.

Section 3007--Inspections:

This section requires any person who generates, stores, treats, transports, disposes of, or otherwise handles hazardous wastes to allow access to records relating to these wastes to any officer or employee of the Environmental Protection Agency designated by the Administrator or any duly designated officer or emplyee of a state having an authorized hazardous waste program. Such officers or employees are authorized:

> To enter at reasonable times any establishment or other place maintained by any person where

hazardous wastes are generated, stored, treated, or disposed of.

> To inspect and obtain samples from any person of any such wastes and samples of any containers or labeling for such wastes.

Procedures are given for conducting such inspections. In addition, provisions are made for the public to obtain records, reports, or information.

Section 3008--Federal Enforcement:

Procedures are given for the issuance of a compliance order and the commencement of a civil action in the event the administrator determines that any person is in violation of any requirement of Subtitle C. A public hearing may be requested by the person or persons named in the order or permit revocation. Provision is made for criminal penalties for violations of Subtitle C.

Section 3009--Retention of State Authority:

Under this section no state may impose any requirements less stringent than those authorized under Subtitle C, except that if application of a regulation under Subtitle C is postponed or enjoined by the action of any court, a state may not be prohibited from acting on the matter until the regulation takes effect.

Section 3010--Effective Date:

This section requires any person generating or transporting hazardous wastes or owning or operating any facility for treatment, storage, or disposal of hazardous wastes to file a notification with the Administrator within 90 days of the promulgation or revision of regulations under Section 3001. The regulations under Subtitle C respecting requiremetns applicable to the generation, transportation, treatment, storage, or disposal of hazardous waste shall take effect six months after their date of promulgation.

Section 3011--Authorization of Assistance to States:

Section 3011 authorizes 25 million dollars for fiscal years 1978 and 1979 "to be used to make grants to the States for purposes of assisting the states in the development and implementation of authorized state hazardous waste programs."

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